House of Commons

Science and Technology Committee

Astronomy and Particle Physics

Fourth Report of Session 2010–12

HC 806

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Report, together with formal minutes, oral and written evidence

Additional written evidence is contained in Volume II, available on the Committee website at www.parliament.uk/science

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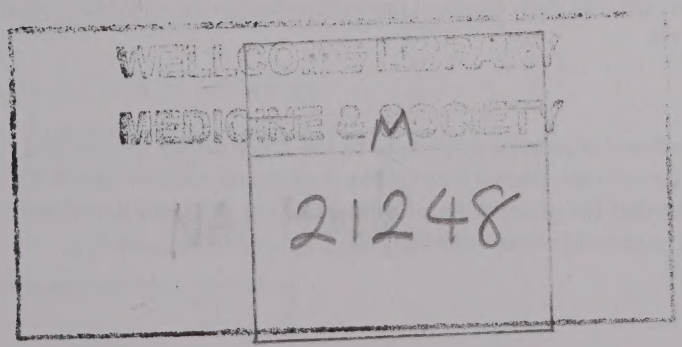

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The Science and Technology Committee

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Contents

Report

Summary

As a result of the 2010 Spending Review, science funding over the next four years will be standing still and there will be increased emphasis on research impacts, and national and strategic priorities. There is concern that fundamental and theoretical subjects such as astronomy and particle physics, which do not provide immediate economic returns, may now be vulnerable.

The Science and Technology Facilities Council (STFC), which funds much research into astronomy and particle physics, received a relatively good settlement. STFC funding for astronomy, however, sees a reduction in both its resource and capital budgets by the end of the four years compared with 2010/11, with an overall fall of 21% in the total astronomy budget by 2014/15. In contrast, particle physics sees a small increase in its total budget of 5% over this period, although increases in its resource budget masks a large fall in the capital budget for particle physics.

When put in a wider context the situation is worrying for both astronomy and particle physics. By 2014/15 spending in both of these areas will be around 50% lower than its 2005 level. The STFC and the astronomers gave us conflicting analyses. The STFC pointed to decisions taken in 2002 when the UK decided to join the European Southern Observatory (ESO). This resulted in additional expenditure over the following years that had to be offset by future spending reductions and withdrawal from northern hemisphere ground-based optical and infrared facilities. Others contended that the STFC's strategy was not so clear cut, and that ESO accession did not justify all future spending reductions and withdrawals. While we accept that there was a stated long-term intention to withdraw from some facilities following ESO accession, we took the view that the decision to join ESO does not provide cover for all future reductions in spending on astronomy. We find it inexplicable that the planned withdrawals at the time of ESO accession were not incorporated into all subsequent PPARC and STFC policy documents. Unfortunately, this failure by STFC to communicate is chronic and typical and is the reason why its client communities have such a low opinion of it.

We are concerned about the impact withdrawal from astronomical facilities will have on UK astronomy. It is essential that the STFC re-examine the case for maintaining UK access to some ground-based optical and infrared telescopes in the northern hemisphere, especially in light of the relatively small amount of money that would allow continuity. In our view it is crucial that, if the UK is to continue to attract, train and retain the very best scientists, and reap the future economic and social rewards, the STFC must ensure it invests in the full range of astronomical facilities. Reductions in funding on astronomy and particle physics over the next four years will determine whether the UK has a significant part to play in these fields for decades to come, and this fact must not be overlooked.

The STFC must also look to continue to improve its communication and engagement with the researchers and scientists that it funds. While it is clear to us that some lessons from earlier failures in communication and engagement have been learned, there is still a large amount of room for improvement and the STFC must commit to working with researchers and academics, and acting as an advocate for all of the science disciplines it covers.

Finally, if the UK's supply of astronomers and particle physicist is to be ensured for future generations to come it is important that every effort is made to inspire young people to study science. We believe the STFC must formally look to encourage researchers and scientists to make outreach and public engagement activities an integral part of their role. Furthermore, the STFC must exploit its network of strategic partners in the public sector, universities, learned societies and industry and act as a conduit in developing, coordinating and promoting a formal programme of outreach between these partner organisations and schools. To achieve this, the STFC and others must first overcome the 'silo mentality' which we found still pervades government and means relatively cost-effective educational research projects, such as the National Schools Observatory, which are so important to inspiring the next generation of scientists, risk being lost.

1 Background

The Science and Technology Facilities Council

1. The Science and Technology Facilities Council (STFC) is the newest Research Council, created in 2007 from a merger of two existing research councils: the Council for the Central Laboratory of the Research Councils (CCLRC) and the Particle Physics and Astronomy Research Council (PPARC). This brought together the grant-giving function of PPARC with the large facilities managed, and subscribed to, by the CCLRC. The rationale for the merger was to "create a more integrated approach to large scientific research facilities".[1] The STFC funds researchers in universities directly through grants, particularly in particle physics, astronomy, and nuclear physics. It also provides grants for facility development and supports research infrastructure, training, knowledge exchange and public engagement activities through a variety of funding schemes and activities.[2]

The work of predecessor committees

2. Concerns arising from the formation of the STFC and its first few years of operation, in particular related to its finances, structure and relationship with the researchers that it funds, were addressed in two reports by our predecessor committees.

3. First, the former Innovation, Universities, Science and Skills Committee's 2008 report, *Science Budget Allocations,* concluded that the budget formed by the combined budgets of PPARC and CCLRC was insufficient and this, coupled with the merger of the two councils to meet the deadline of the 2007 Comprehensive Spending Review, had resulted in a shortfall in its spending review allocation of around £75 million.[3] The Committee also criticised the STFC's failure to consult on withdrawal from a number of international scientific facilities[4] and believed there were serious questions over the ability of the Chief Executive to command the confidence of the scientific community.[5] Concerns were also raised over the impact STFC budget reductions might have had on research and facilities beyond those that it directly funded or owned, such as the Jodrell Bank Observatory near Manchester.[6]

4. Second, the previous Science and Technology Committee's 2010 report, *The impact of spending cuts on science and scientific research,* highlighted particular problems with the structure of the STFC upon its formation which had led to the STFC's grant-giving functions being "financially tensioned" against its commitments to international

[1] Third Delegated Legislation Committee, *Draft Science and Technology Facilities Council Order 2007 and Draft Technology Strategy Board Order 2007,* 11 December 2006, col 5

[2] "STFC Grants and Awards", STFC webpage: www.stfc.ac.uk/Funding+and+Grants/501.aspx, 21 July 2010

[3] Innovation, Universities, Science and Skills Committee, Fourth Report of Session 2007–08, *Science Budget Allocations,* HC 215–I, para 39

[4] HC 215–I (2007–08), para 87

[5] HC 215–I (2007–08), para 108

[6] HC 215–I (2007–08), para 89

subscriptions and the associated cost pressures arising from exchange rate fluctuations.[7] The Committee also recommended that withdrawals from programmes following the STFC's 2009 prioritisation exercise (see below) should be suspended until after the 2010 Spending Review when budget allocations for 2011/12 to 2014/15 would be known.[8]

2009 STFC prioritisation exercise

5. In 2009, the STFC carried out a Science Programme Prioritisation for the period 2010 to 2015. This was carried out for two reasons: to prepare for tougher budget outcomes expected as a result of national budgetary constraints; and to ensure the STFC's programmes delivered maximum scientific, social, economic and international benefit to the UK.[9] During the prioritisation exercise the STFC commissioned an independent panel to review the astronomical ground-based facilities supported by the STFC.[10] The panel placed:[11]

- "very high priority" on the UK's ongoing involvement in the European Southern Observatory (ESO) and future involvement in the development and operation of two future astronomical projects, the European-Extremely Large Telescope (E-ELT) and the Square Kilometre Array (SKA);
- "high priority" on ongoing access to the William Herschel Telescope (WHT) on La Palma to 2017 (one of the Isaac Newton Group (ING) part-owned by the STFC), and the two telescopes located at the STFC's Joint Astronomy Centre in Hawaii—the James Clerk Maxwell Telescope (JCMT) to 2014, and the UK Infrared Telescope (UKIRT) to 2014—in addition to a number of other facilities; and
- "medium priority" on an ongoing share in the Gemini telescope in Hawaii.[12]

6. Following the prioritisation programme, the STFC announced the managed withdrawal from a range of projects, programmes and facilities.[13] In particular the STFC said it would be withdrawing from a number of ground-based astronomical facilities, including Gemini (from 2012), the ING telescopes including the WHT (from 2012), the Liverpool Telescope on La Palma, the JCMT (from 2012) and the UKIRT.[14]

7. A full summary of the STFC's decisions in relation to astronomy and particle physics projects following the prioritisation exercise is provided at Annex 2 to this report.

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[7] Science and Technology Committee, Sixth Report of Session 2009-10, *The impact of spending cuts on science and scientific research*, HC 335, para 51

[8] HC 335 (2009–10), para 52

[9] "Science Programme Prioritisation 2010–2015", STFC Press Release, 16 December 2009

[10] STFC, *Ground-Based Facilities Review Final Report*, 2009; the Chair and Vice-Chair of the panel have both submitted evidence to the inquiry (Ev w20 [Professor Michael Rowan-Robinson and Professor Robert Kennicutt]; and Ev 43 [Professor Robert Kennicutt]).

[11] To assist the reader there is a glossary of acronyms and abbreviations at Annex 1 to this report.

[12] The Panel's final priority list is summarised at Annex 2.

[13] "Science Programme Prioritisation 2010-2015", STFC Press Release, 16 December 2009

[14] Support for the UKIRT has been extends to 2013, while there is also a "limited extension" to support for the JCMT (Ev 52, para 12 [Science and Technology Facilities Council]).

Descriptions of selected ground-based astronomical facilities with UK involvement are set out at Annex 3.

2010 Spending Review

8. The 2010 Spending Review, published on 20 October 2010, set spending limits for every Government department for the four year period 2011/12 to 2014/15.[15] As part of the Department for Business, Innovation and Skills' (BIS's) settlement, it was announced that the resource expenditure element of the science budget would remain ring-fenced and maintained in cash terms over this period at £4.6 billion a year. The impact on individual components of the science budget, its capital elements, and in particular individual Research Council budgets was not announced until 20 December 2010 with the publication of the BIS document, *The Allocation of Science and Research Funding 2011/12 to 2014/15.*[16]

9. Table 1 below displays the resource budget allocations for each of the Research Councils over the next four years compared with 2010/11. The allocation for the Large Facilities Capital Fund (LFCF) is also shown. The LFCF supports Research Councils' investments in large research facilities with capital funding where that could not be sensibly accommodated within individual Research Council budgets. The capital allocations are "indicative" for the three years from 2012/13 to 2014/15.[17]

[15] HM Treasury, *Spending Review 2010*, October 2010, Cm 7942, Tables 1, 2 and 2.9 and paras 2.47–2.49

[16] BIS, *The allocation of science and research funding 2011/12 to 2014/15*, December 2010

[17] BIS, *The allocation of science and research funding 2011/12 to 2014/15*, December 2010, p 19

Table 1: Research Council budget allocations

£000s

	2010-11 (baseline)	2011-12	2012-13	2013-14	2014-15	Totals	Final year to baseline
Resource budget							
AHRC	100,717	99,881	98,370	98,370	98,370	394,993	97.7%
BBSRC	362,341	370,306	359,471	351,471	351,471	1,432,718	97.0%
EPSRC	771,289	759,720	748,150	748,150	748,150	3,004,171	97.0%
ESRC	158,061	155,690	153,319	153,319	153,319	615,648	97.0%
MRC	545,585	536,172	546,243	559,894	574,641	2,216,950	105.3%
NERC	298,071	298,600	297,129	300,129	289,129	1,184,987	97.0%
STFC core programme	177,519	190,060	172,200	172,200	172,190	706,650	97.0%
STFC cross-council facilities (a)	66,800	77,170	79,280	81,410	89,470	327,330	133.9%
STFC International Subscriptions (b)	68,970	108,598	119,515	121,697	123,071	472,881	178.4%
Total	2,549,353	2,596,196	2,573,678	2,586,641	2,599,812	10,356,327	102.0%
Capital budgets							
AHRC	3,150	0	0	0	0	0	0.0%
BBSRC	66,480	38,000	29,700	29,700	29,700	127,100	44.7%
EPSRC	49,261	31,000	35,000	25,000	25,000	116,000	50.8%
ESRC	20,600	18,700	13,700	12,700	12,700	57,800	61.7%
MRC	134,517	33,000	29,000	31,000	31,000	124,000	23.1%
NERC	34,183	32,200	17,800	17,800	17,800	85,600	52.1%
STFC core programme		19,630	21,981	14,237	14,169	70,017	
STFC cross-council facilities		21,070	21,919	22,463	22,931	88,383	
STFC International Subscriptions		46,221	30,293	28,530	27,667	132,711	
STFC total	85,247	86,921	74,193	65,230	64,767	291,111	76.0%
Total	393,438	239,821	199,393	181,430	180,967	801,611	46.0%
Large Facilities Capital Fund	103,380	115,279	61,307	47,769	128,132	352,487	123.9%

Notes:

(a) operated by STFC on behalf of all Research Councils

(b) Managed by STFC on behalf of all Research Councils. Total resource expenditure on international subscriptions in 2010-11, including the additional exchange rate costs was £103m.

The SR10 allocations are at the exchange rates prevailing in early December 2010 and reflect a shift in funding from capital to resource.

Source: BIS, The allocation of science and research funding 2011/12 to 2014/15, December 2010

10. The STFC "core programme" annual resource budget will be 3% lower in cash terms in 2014/15 compared with 2010/11. However, following decisions made by the previous Government, the allocation included separate budgets for the STFC's international subscriptions and cross-council facilities in order to better manage cost pressures arising from exchange rate fluctuations and also the longer-term planning required for large domestic facilities.[18] Therefore, overall the STFC's total annual resource budget will be 23% higher in 2014/15 compared with 2010/11.

11. However, while the resource science budget received relative protection, the capital budget did not. It reflects BIS's overall spending review settlement to reduce its capital budget by 44% in cash terms over the next four years.[19] Although the STFC has received the most protection (its capital budget will actually increase slightly in cash terms in 2011/12 by 2%), by 2014/15 it will be 24% lower compared with 2010/11. To put this in context, the total Research Councils' annual capital budget will be 54% lower in cash terms in 2014/15 compared with the 2010/11 level.

[18] BIS, *STFC: New arrangements to provide stability in research funding*, 4 March 2010

[19] Cm 7942, Table 2.9

Resource and capital funding for astronomy and particle physics: 2010/11 to 2014/15

12. The importance of investment in astronomy and particle physics research in the UK and concerns over future funding in these areas were common theme throughout the written evidence we received. For example, Professor Stephen Hawking, Director of Research at the University of Cambridge's Centre for Theoretical Cosmology, said:

> to target funding only using narrow economic criteria is to misunderstand the value to society of science and our Universities. [The] frontiers of fundamental scientific knowledge, like particle physics and astronomy, have always been an inspiration for the next generation of scientists. [The] UK punches significantly above its weight in the competitive world of particle physics and astronomy and has a remarkable history of discoveries and fruitful international collaboration. [Without] strong support for subjects like particle physics and astronomy we will suffer the economic and cultural consequences of a lack of students in the physical sciences.[20]

13. As we noted above, the STFC obtained a relatively good settlement in the overall context of the science and research budget allocations for the next four years, particularly its resource budget. Table 2 below sets out the STFC's spending on astronomy and particle physics over the next four years compared with the final year (2010/11) of the previous spending review period.

Table 2: STFC resource and capital spending by theme

£ million

	2010/11 (baseline)		2011/12		2012/13		2013/14		2014/15	
	Resource	Capital	Resource	Capital	Resource	Capital	Resource	Capital	Resource	Capital
Astronomy										
Subscriptions (ESO)	10.9	18.3	11.6	17.8	11.7	7.2	11.6	7.4	11.5	7.6
Development	3.2	1.9	5.0	2.0	7.4	2.0	8.8	2.0	9.8	2.0
Operation/exploitation	46.2	4.4	45.4	0.5	37.9	0.5	33.2	0.5	32.5	0.5
Studentships/Fellowships	15.0	0.0	15.3	0.0	15.1	0.0	14.9	0.0	15.2	0.0
Total	**75.3**	**24.6**	**77.3**	**20.3**	**72.0**	**9.7**	**68.5**	**9.9**	**68.9**	**10.1**
Particle Physics										
Subscriptions (CERN)	63.6	32.9	81.8	21.6	89.4	15.4	90.5	15.3	92.4	15.2
Development	8.5	2.6	11.1	2.4	11.4	2.4	13.0	2.4	14.2	2.4
Operations/exploitation	35.0	5.5	30.5	0.5	30.6	0.5	30.9	0.5	31.8	0.5
Studentships/Fellowships	9.6	0.0	9.8	0.0	9.7	0.0	9.6	0.0	9.8	0.0
Total	**116.7**	**41.0**	**133.2**	**24.5**	**141.1**	**18.3**	**143.9**	**18.2**	**148.2**	**18.1**

Notes: 2011/12 Capital for ESO includes the final capital special payment relating to accession to ESO
Capital for operations /exploitation lines divided between Astronomy, Particle Physics and Nuclear Physics on a pro rata basis - and therefore included for indicative purposes only.

Source: Ev 54, Science and Technology Facilities Council

14. Astronomy sees a reduction in both its resource (-8%) and capital (-59%) budgets by the end of the next four years compared with 2010/11, with an overall fall of 21% in the total (resource plus capital) astronomy budget from £100 million in 2010/11 to £79 million in 2014/15. In contrast, particle physics sees a small increase in its total (resource plus capital) budget of 5% over this period (from £158 million to £166 million), although

[20] Ev w27–28, paras 1–3

increases in its resource budget (+27%) masks a large fall in the capital budget for particle physics (-56%).

15. While overall particle physics spending is set to increase in cash terms, evidence from the Institute of Physics indicated that, when spending on the CERN subscriptions was stripped out and inflation was taken into account, the particle physics *resource* budget would see a reduction in the region of 50% over the period 2005 to 2015.[21] Professor John Peacock, Head of the University of Edinburgh's Institute for Astronomy, estimated that real-terms *resource* funding for astronomy was set to be half the 2005 level by 2014 when the STFC's European Southern Observatory (ESO) subscription is excluded.[22] A number of submissions cited the financial problems at the time of the STFC's formation in 2007, which resulted, as we have noted in a £75 million budget shortfall over the ensuing three years, as one of the main reasons for such large historical reductions in astronomy and particle physics spending.[23]

Our inquiry

16. The funding of science is key to future economic growth. The Committee therefore took a very close interest in the 2010 Spending Review settlement and the resulting science and research budget allocations for the next four years. We have, to date, held two evidence sessions on these issues: on 24 November we took evidence from the Minister for Universities and Science, Rt Hon David Willetts, and BIS's (then) Director General for Science and Research, Sir Adrian Smith; and on 19 January 2011 we took evidence from four Research Council Chief Executives.[24] While these sessions gave us some reassurance, we were not clear about the full impact of the science and research budget allocations for the next four years, and we had particular concerns about issues that arose regarding the future funding of astronomy and particle physics by the STFC.

17. Following these sessions, on 26 January we announced our intention to invite representations from the wider scientific community and other interested parties on the future impact of the science and research budget allocations, with a view to reviewing which areas may need further examination following the Easter recess. However, our concerns about astronomy and particle physics were such that, in the meantime, we took the decision to carry out a short inquiry into the future funding of these two fields of science in the UK. To this end, we issued a call for evidence on 26 January seeking views on the following issues:

- the impact of reduced capital funding on UK capability;
- the impact of withdrawal from international ground-based facilities (for example the Gemini Observatory and Isaac Newton Group of telescopes) on the UK's research base and international reputation;

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[21] Ev 49, para 5

[22] Ev 99, para 3

[23] See, for example: Ev w7 [Durham University], para 2; Ev 46, para 7 [Institute of Physics]; Ev 100, paras 6–7 [Professor John Peacock]; and Ev 104, para 9 [Professor Patrick Roche]

[24] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618-i and ii; the transcripts to both of these sessions are available on our website.

- whether the STFC has sufficiently engaged with its research community in these two areas on its strategic direction and impacts of budget reductions; and

- opportunities for, and threats to, outreach and inspiring the next generation of astronomers and particle physicists.

18. We received 41 written submissions in response to our call. We would like to thank all those who submitted written memoranda.

19. During March, we took oral evidence from five panels of witnesses, to whom we are grateful. The first two panels focused on issues associated with point four of our terms of reference, while the remaining three panels addressed issues across the inquiry's full terms of reference. The panels were as follows:

i. Anna Barth, Camden School for Girls, London, Jack Bliss, Allerton Grange School, Leeds, Jessica Grainger, Saints Peter and Paul Catholic College, Widnes, Hilary Lamb, Stroud High School, Gloucestershire, James May, Castell Alun High School, Hope (nr. Wrexham), and Charlie Palin, Neston High School, Cheshire;

ii. Dr. Maggie Aderin-Pocock, Space Scientist, Astrium Ltd and Science Innovation Ltd, and Professor Jim Al-Khalili, Professor of Physics, Professor of Public Engagement in Science, University of Surrey;

iii. Professor Dame Jocelyn Bell Burnell, President, Institute of Physics, and Professor Roger Davies, President, Royal Astronomical Society;

iv. Professor Phil Allport, Head of Particle Physics and Director of the Liverpool Semiconductor Detector Centre, University of Liverpool, Professor Mike Bode, Director of the Astrophysics Research Institute, Liverpool John Moores University, Professor Robert C. Kennicutt, Jr., Plumian Professor of Astronomy and Experimental Philosophy Director, Institute of Astronomy, University of Cambridge, Professor John Peacock, Head of the Institute for Astronomy, University of Edinburgh, Professor Steve Rawlings, sub-Department of Astrophysics, Oxford University, and Professor Andrei Seryi, Director, John Adams Institute for Accelerator Science; and

v. Professor Keith Mason, Chief Executive of the STFC, and Sir Adrian Smith, Director General, Knowledge and Innovation, Department for Business, Innovation and Skills (BIS).

20. We also supplemented our evidence with a short visit to the European Organisation for Nuclear Research (CERN) in Geneva, Switzerland where we were pleased to meet many British researchers working in collaboration with their international peers. We would like to thank all those individuals that took the time to meet with us during our visit.

21. A number of short-term and long-term factors led us to launch this inquiry, and they informed our approach to the subject:

- the scale of the reduction in the astronomy budget compared with the STFC's overall budget settlement, and the lack of clarity on the past and future astronomy strategy of the STFC and its predecessor;

- the UK's continued capacity to benefit from, and be involved in, the wide range of practical applications and future development in particle physics, as described to us during our visit to CERN;
- that fundamental and theoretical research in areas such as astronomy and particle physics, which do not necessarily provide immediate returns but are crucial to the UK's long-term growth prospects and international standing, may be vulnerable following the increased emphasis placed on research impacts, national and strategic priorities, and growth by the Government;[25] and
- the UK's ongoing ability to inspire, train and attract the next generation of astronomers and particle physicists.

These key concerns are embedded in many of the issues that we look at in this report. Chapter 2 discusses reductions in the astronomy budget and the STFC's strategy in this area. Chapter 3 analyses other funding issues which will be important to the UK's ongoing standing in astronomy and particle physics, including the grants the STFC awards to researchers, and the STFC's capital allocation for the next years, and in particular the impact this will have on the UK's involvement in instrumentation research and development and future particle accelerator technologies. Chapter 4 evaluates how the STFC communicates and engages with the researchers it funds, while Chapter 5 looks to the future and the next generation of scientists. Both of these final issues are clearly integral to maintaining the UK's human capital in astronomy and particle physics and as a consequence ensuring the UK's long-term growth prospects and international standing.

[25] See, BIS, *The allocation of science and research funding 2011/12 to 2014/15*, December 2010; and HC Deb 20 December 2010 cc135–38WS.

2 Reductions to the astronomy budget

An over investment and strategic planned withdrawal?

22. Given the relatively large reduction in astronomy funding over the next four years compared with the overall STFC budget settlement, the first question we had to consider was what the reason for this was. On 19 January we asked Professor Keith Mason, Chief Executive of the STFC, about these future reductions in funding for astronomy. He said that decisions made over the past decade prior to, and following, UK accession to the European Southern Observatory (ESO) in 2002 had resulted in a planned period of higher spending on astronomy:

> when we joined ESO in 2002–03 we still had commitments to a range of other ground-based observatories. So we recognised that in joining ESO we would be over-investing in astronomy for a period of a decade because we had to stay in these other facilities. As we withdraw from those facilities, the astronomy budget will go back down to what it ought to have been if we had been able to make that transition suddenly.[26]

23. Professor Mason also said in January that the STFC's planned withdrawal from Northern Hemisphere ground-based infrared and optical astronomical facilities, announced in 2009, was the result of a long-term strategic decision to concentrate resources, dating back to the plans made prior to ESO accession:

> It's really a scientific dilemma. [Do] you concentrate your resources in producing the very best facilities that might be in a single location, or do you spread those resources in order to cover a broader set of activities? [The] strategic decision that was made a decade ago was to recognise that we do need to concentrate and stay at the forefront of activities. We had a choice to make. Do we do that through ESO or by some other means? I think the right decision is to do it through ESO.[27]

24. The thrust of both these statements was disputed in the evidence we received.[28] That is:

a) that there had been a planned period of over-investment in astronomy following accession to the ESO; and

b) that the STFC was concentrating its activities on the ESO for scientific reasons which would result in withdrawal from Northern Hemisphere facilities.

25. On the first point, the Royal Astronomical Society stated that this was contrary to the "recollection" of UK astronomers at the time, and was "not supported by any documentary

[26] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 130

[27] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 128

[28] See, for example: Ev 41–42, paras 29–31 [Royal Astronomical Society], Ev 43, para 2 [Professor Robert Kennicutt], Ev w39, para 14 [University of Manchester]

evidence that we are aware of",[29] and it also questioned whether withdrawal from Northern Hemisphere facilities was part of a long-term strategy following ESO accession:

> When the UK joined ESO it was recognised that we would scale back our involvement in some facilities [but] the plan now being implemented goes far beyond that. The decision to implement a complete withdrawal was made for financial rather than scientific reasons, in contrast to the statement made to the Committee.[30]

26. However, it was acknowledged by Professor John Peacock, Head of the University of Edinburgh's Institute for Astronomy, that there was to be an implicit temporary increase in astronomy spending in the years following ESO accession. While he refuted the notion that, prior to the financial problems caused by the STFC's formation in 2007, there had been any strategic plan to reduce investment and activities in the coming years, he said that:

> A pulse of money went into UK astronomy which was always intended to be temporary. When we joined ESO, we immediately had access to their telescopes that had been created over decades. As well as paying your annual subscription, there was a back payment to buy our share of ownership of those things. Even in 2002, when this happened, you could see a spreadsheet where there was this pulse of several millions a year, which, yes, was over-investment, and it was scheduled to stop about now and it has.[31]

27. We understand that much of the *capital* reduction in the astronomy budget in the three years after 2011/12, as set out in Table 2 at paragraph 13, is explained by the ending of the UK's additional contributions, as described by Professor Peacock, that were part of the price of ESO accession and will amount to around £10 million in 2011/12, the final year for which such a payment is required. In other words, that is why the ESO capital budget falls from about £18 million in 2011/12 to about £7 million per year from 2012/13. The UK's additional contributions to ESO, totalling €72 million over the period 2004/05 to 2011/12,[32] represent the UK's agreed share in capital investment and fitting out costs which had already been incurred for the ESO's Very Large Telescope.[33] It would have assisted us if the STFC had explained to us such specific consequences of joining the ESO.

STFC clarification

28. When we asked the STFC again at the evidence session on 16 March about the planned period of over investment and associated withdrawal from some non-ESO astronomical facilities, what he did was "clarify" his previous remarks to us.[34] Professor Mason said that plans for withdrawal from non-ESO facilities had been a financial rather than scientific

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[29] Ev 41, para 29

[30] Ev 42, para 31

[31] Q 96

[32] This equated to approximately £50 million at the time of ESO accession, although exchange rate fluctuations mean the sterling value of the annual contribution has risen over the ensuing years.

[33] Ev 55 [Science and Technology Facilities Council]

[34] Q 129

strategy, and cited a 2001 PPARC paper proposing UK accession to the ESO which was considered at a PPARC Council meeting on 5 December 2001:[35]

> Perhaps it would be helpful if I quoted to you from the papers that were looked at in 2001, on 5 December, from the PPARC Council meeting, concerning the accession to ESO. [It] says: "Note that the above programme represents the first phase in re-shaping PPARC's investment in ground-based astronomy facilities over the next decade. The long-term strategy will see PPARC withdraw from the [Anglo-Australian Telescope (AAT), James Clerk Maxwell Telescope (JCMT), UK Infrared Telescope (UKIRT) and the Isaac Newton Group of telescopes (ING)] by the end of the decade." So that was the financial strategy that PPARC adopted in 2001 as part of the arrangements for the affordability of entry into ESO.[36]

29. We have now been given sight of the quoted document and its annexes, all of which are published in the written evidence to this report.[37] The document does provide details of the long-term financial restructuring required following ESO accession and the consequential planned withdrawal from those ground-based facilities detailed above. However, we note that it did not include any indication of eventual withdrawal from the Gemini Observatory. Indeed, Annex 2 to the document, which provided further background to the proposed strategy for the ground-based programme, prioritised UK involvement in Gemini alongside the ESO.

30. The 2001 PPARC paper also detailed the additional contributions to ESO required up to 2011/12 and laid out how savings of around £5 million by 2005/06 would be made from restructuring operations at other ground-based astronomical facilities in order to finance an element of the additional ESO contributions, with these savings rising to over £11 million by 2011/12. Annex 2 to the document reiterated that the long-term consequences of adopting this financial strategy would mean withdrawal from the facilities quoted by the STFC above.[38] Annex 3 to the document detailed the then PPARC Science Committee's recommendations to the Council following consideration of the proposed strategy:

> After a detailed discussion, [the Science Committee] formed the opinion that the savings described [effectively] meet the requirements necessary for the UK to proceed to ESO membership, whilst in the medium term permitting focussed and highly cost effective participation at a reduced level in the world-class science output from existing facilities.[39]

31. Following our evidence session on 16 March, five of the astronomers who appeared before us that day submitted a supplementary memorandum pointing out that:

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[35] Q 129

[36] As above

[37] Ev 55 [Science and Technology Facilities Council]

[38] Although it withdrew from the AAT in 2010, the STFC is still involved in the JCMT, UKIRT and ING, although current plans are for withdrawal from all of these telescopes and more within the next three years (see from paragraph 35 below)

[39] Ev 55 [Science and Technology Facilities Council]

> the position advocated by [the STFC] is not incorporated in subsequent strategy documents (for example, the 2005-2008 delivery plan). [The] UK astronomical community has made more than double the savings identified as needed in order to join ESO. [The] statement of the STFC Chief Executive does not correctly reflect the clear strategic position developed with regard to the non-ESO telescopes at the time of ESO accession. [The] idea that this process might be overturned by a single sentence [as quoted by the STFC] in a paper developed by the PPARC Executive is hardly credible, unless one favours the sort of decoupled decision-making that has been strongly criticised as an undesirable trait of the early days of STFC.[40]

Conclusions

32. **Given the evidence and documentation presented to us, we accept that there was a stated long-term intention to withdraw from some facilities following ESO accession. We note and welcome the clarification by the STFC that this was a financial rather than scientific strategy.**

33. **However, while ESO accession required some strategic restructuring of UK investments, as set out in the 2001 PPARC papers, the strategic decision does not provide cover for all future reductions in spending on astronomy. We find it inexplicable that the planned withdrawals detailed in the 2001 PPARC papers were not incorporated into all subsequent PPARC and STFC policy documents. This would have given the UK astronomical community the opportunity to challenge this policy in more detail, particularly as it was suggested to us that more than double the savings had been made than were required to join ESO. Unfortunately, this failure by STFC to communicate is chronic and typical and is the reason why its client communities have such a low opinion of it.**

34. **For the benefit of transparency, we recommend that the STFC make publicly available all PPARC and STFC council minutes and strategy documents which discuss UK spending on, and involvement in, ground-based astronomical facilities over the last ten years.**

Withdrawal from ground-based astronomical facilities

35. The extent of the UK's future withdrawal from non-ESO facilities increased two years ago following the STFC's 2009 prioritisation programmes (as described in paragraph 5), and the consequences of this are apparent in some of the reduction in astronomy spending over the next four years shown in the Table 2 at paragraph 13. Following the prioritisation programme, the STFC announced[41] it would be withdrawing from facilities including Gemini (from 2012), the ING telescopes (from 2012), the Liverpool telescope, the JCMT (from 2012) and the UKIRT.[42] The STFC told us in January that following withdrawal

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[40] Ev 101 [Professor John Peacock; co-signed by Professor Mike Bode, Professor Roger Davies, Professor Rob Kennicutt and Professor Steve Rawlings]

[41] Science Programme Prioritisation 2010–2015", STFC Press Release, 16 December 2009

[42] Support for the UKIRT has been extends to 2013, while there is also a "limited extension" to support for the JCMT (Ev 52, para 12 [Science and Technology Facilities Council]).

from such facilities, its future ground based astronomy strategy would be focused through the facilities operated and developed by the ESO.[43]

Impacts of withdrawal

36. These withdrawals would mean that, within a few years, the UK and its astronomers will not have any direct access to ground-based optical and infrared observatories in the Northern Hemisphere,[44] although the UK will continue to be involved in a number of space-based observatories which observe objects across the whole sky.[45] There are also a number of radio observatories in the Northern Hemisphere which the UK will continue to have access to.[46] Thus, while UK researchers will be able to study objects in the northern part of the sky using these observatories, they will have no optical or infrared facilities with which to follow up their work.[47] The Royal Astronomical Society said withdrawal might mean UK scientists who make discoveries using a space based or radio observatory would see leadership of their work pass to peers in other ESO member states such as Germany, Italy, France, the Netherlands and Spain, who all plan to retain access to other optical and infrared facilities in the Northern Hemisphere.[48]

37. Professor Janet Drew, Director of the Centre for Astrophysics Research at the University of Hertfordshire, and chair of the Astronet[49] European Telescopes Strategic Review Committee which reported in 2010, emphasised the role of the ING's William Herschel Telescope in supporting the European Space Agency's future Gaia mission:[50]

> What a waste if the UK, who created the William Herschel [one of the ING telescopes on La Palma], could have no part in its further use, with a state-of-the-art instrument. Is all the investment of the past just to be handed over to our European colleagues in a gift of future science leadership?[51]

38. Strong arguments were also made to us about the educational and training benefits of UK involvement in telescopes such as those on La Palma,[52] and the shortcomings of concentration on the ESO from a strategic scientific viewpoint. Professor Peacock argued that as ESO is a shared resource, in order to gain a competitive advantage, the UK needed to retain some of its own telescopes:

> which we can turn into specialized facilities delivering data that can be combined with ESO results in a way that is not available to our European colleague-

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[43] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 126

[44] Ev 40, paras 10 and 14 [Royal Astronomical Society]

[45] For example, the Herschel Space Observatory, Planck, GAIA, and the James Webb Space Telescope

[46] For example, Jodrell Bank, the Multi-Element Radio Linked Interferometer Network (e-MERLIN) array and LOFAR

[47] Ev 40, para 14 [Royal Astronomical Society]

[48] Ev 40, para 15

[49] Astronet brings together national agencies, including STFC, to develop a pan-European approach to astronomy.

[50] The Gaia spacecraft mission aims to chart a 3D map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy.

[51] Ev w40

[52] See, for example: Ev w9, para 3d [John Beckman]; Ev w28 [Dr Don Carlos Abrams]; Ev w30, para 13 [Dr Marc Balcells]; Ev w45, para 5 [Chris Benn].

> competitors. [There] is ample scientific reason to persist with [Hawaii and La Palma], assuming a very modest level of funding can be found.[53]

39. Professor Patrick Roche, Head of Astrophysics at Oxford University, said UK withdrawal from Northern Hemisphere facilities would make the development of innovative UK-led instrumentation projects "much more difficult".[54] In the case of the ING telescopes, the STFC's involvement allowed UK university teams the opportunity to deploy their own instrumentation, while the ING's William Herschel Telescope was the only available facility where the adaptive-optics technologies needed for the future European Extremely Large Telescope can be prototyped.[55]

Future UK involvement

40. When giving oral evidence, we asked Professor Roger Davies, President of the Royal Astronomical Society, how much it would cost for the UK to maintain some access to Northern Hemisphere observatories. Professor Davies estimated that it would cost the STFC £2-3 million more a year—a "banker's bonus" as Professor Dame Jocelyn Bell Burnell, President of the Institute of Physics, put it.[56] In its written evidence the Royal Astronomical Society provided detailed figures on the estimated additional cost of maintaining a presence specifically within the ING telescopes on La Palma, which are part-owned by the UK:

> Current operational costs for the ING site are around €3.5m (£2.9m) per annum, with €1.3m (£1.08m) of this paid by the UK. This budget has already been pared to a minimum and funds only a limited operation. A more realistic UK contribution for full operations is around €1.5m (£1.26m) per annum. To remain competitive in the future the observatory needs to develop new instruments such as the new wide-field multi-object spectrometer which is now under consideration. A sensible figure for the annual UK budget requirement is €2.5m (£2.1m) per annum. Without an investment of this kind to recover access to northern hemisphere facilities we fear that UK astronomy will be internationally uncompetitive.[57]

41. There are two STFC-owned telescopes on Hawaii, the UKIRT and the JCMT. Professor Peacock indicated that the cost of operating these two telescopes was £3 million per annum, although it was likely this cost would fall further with partnership deals.[58] Professor Mike Bode, Director of the Astrophysics Research Institute at Liverpool John Moores University which owns the Liverpool telescope on La Palma, suggested that its continued operation would require around £250,000 per annum from the STFC.[59]

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[53] Ev 100, para 9

[54] Ev 103, para 6

[55] Ev w30, para 12 [Dr Marc Balcells]

[56] Q 78

[57] Ev 41, para 23

[58] Q 106

[59] Q 112

42. We were told that the current cost of UK involvement in Gemini was around £5–6 million per annum.[60] The Gemini UK National Time Allocation Committee said that ongoing access to Gemini with a reduced partner share would reduce costs to around £2–3 million per annum.[61] However, arguments in respect of Gemini where not so clear-cut. The Ground-Based Facilities Review panel, commissioned by the STFC in 2009, accepted that, on cost-effectiveness grounds, continued UK involvement in Gemini might not be justified, but recommended continued involvement in the ING telescopes, in order to mitigate Gemini withdrawal and avoid the loss of all Northern Hemisphere access. In particular, the panel placed a high ranking on the ongoing operation of the ING's William Herschel Telescope through to 2017.[62]

43. While we received some representations that the UK should continue to be involved in the Gemini partnership, particularly given the UK's investment to date,[63] much of the evidence we received accepted that withdrawal from Gemini was inevitable, particularly as it was not a UK-owned facility and the scientific and financial arguments for continued involvement were relatively weaker than for other telescopes, such as those on La Palma.[64]

44. The STFC said that ongoing access to STFC-owned facilities might be possible,[65] a point reiterated in the Government's submission:

> STFC continues to operate STFC-owned facilities in Hawaii (JCMT, UKIRT) and the Canaries (ING) and it is discussing future management arrangements with new partners (Hawaii) and with Spain (Canaries) which may include access to some if not all of these facilities. STFC's science committees will have to consider the case for continued UK investment in these facilities in competition with other demands on its science programme budget.[66]

The STFC confirmed to us in March that it was now making "efforts to retain access to the telescopes on La Palma".[67]

45. **Withdrawal from all Northern Hemisphere ground-based optical and infrared facilities risks, in our opinion, surrendering the UK's prominence in this field to other ESO member states and depriving UK astronomers of a leading role in future discoveries and instrumentation development. It is essential that the STFC re-examine the case for retaining access to those telescope that it owns, especially in light of the relatively small amount of money that would allow continuity. We have concerns that it could be to the detriment of UK astronomy if the UK presence in all ground-based optical and infrared facilities outside of the ESO were to be lost.**

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[60] Q 105

[61] Ev w36, paras 4.2–4.3

[62] Ev 43, para 2 [Professor Robert Kennicutt]

[63] See, for example: Ev w31, para 6 [Professor N Tanvir]; Ev w33, para 3 [Dr Bryn Jones]; Ev w36, para 4.1 [Gemini UK National Time Allocation Committee].

[64] See, for example: Ev w7, para 8 [Durham University]; Ev 43, para 2 [Professor Robert Kennicutt]; Ev 100-, para 9 [Professor John Peacock]; and Q 96.

[65] Ev 52, para 12

[66] Ev 38, para 8

[67] Q 129

Funding of future astronomical projects

46. Turning to future projects, we received evidence expressing concerns about the STFC's ability to commit to future astronomical projects following its budget allocations.[68] The 2009 Ground-Based Facilities Review commissioned by the STFC placed the highest priority on UK participation in two future astronomical facilities—ESO's European Extremely Large Telescope (E-ELT), and the Square Kilometre Array (SKA). The review concluded:

> both these projects [have] the potential of exceptionally high public impact, with benefits for the whole UK scientific research programme. Both projects offer great possibilities of technological innovation and knowledge transfer and can offer UK industry cutting edge involvement in the technologies of the future.[69]

47. The STFC's delivery plan published on 20 December 2010 made no specific mention of the E-ELT or SKA, although Professor Mason said in January he was "hopeful" of finding a way of building the E-ELT.[70] Professor Davies told us that the international arrangements for the future of the E-ELT and SKA were getting "very close" to completion:

> If we are not able to commit at the time that we are asked, then that will be a major setback. We have leading teams. We have the opportunity to take the lead in some areas. Obviously, if we are tardy in committing, that lead will evaporate. It won't evaporate instantly but it will go. Our staff will move. Other countries will say, "We could do that bit." We will suddenly find that, instead of having a leadership role and doing the interesting things that, maybe, lead on to the next thing, we are back doing something less interesting and not in the lead. So the ability to commit to these projects in a timely manner is fundamental to the health of the subject.[71]

48. We asked the STFC in March if there was any doubt over the UK's ongoing commitment to the E-ELT. Professor Mason confirmed that forward provision had been made for UK participation and the STFC was now waiting for the ESO to publish its plan for the construction of the telescope. He added: "Provided that [the plan] meets our objectives and is satisfactory, and I have no expectation that it won't".[72]

49. **We welcome the recent decision to locate the SKA project office at the Jodrell Bank Observatory near Manchester.[73] This will enable the UK to take a leading role in the ongoing development of this project, and reflects the high-regard for UK astronomy and astronomers internationally. This happy conclusion would not have been possible if the STFC had not reversed its original intention to remove funding for the e-MERLIN radio telescope at Jodrell Bank, an issue our predecessors had raised serious concerns about.**

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[68] See, for example: Ev w7, para 7 [Durham University]; Ev w20, para 2 [Professor Michael Rowan-Robinson and Prof Robert Kennicutt]; Ev 45, para 4 [Institute of Physics]; Ev w24, para 6 [Professor Paul Crowther]; and Q 65.

[69] STFC, *Ground-Based Facilities Review 2009 Final Report*, Executive Summary, para 5

[70] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 126

[71] Q 65

[72] Q 134

[73] "Getting ready for the world's biggest ever telescope", STFC Press Release, 2 April 2001

50. **We are concerned that short-term funding constraints may hinder the UK's ability to lead on the ongoing development and construction of priority astronomical projects such as the Square Kilometre Array (SKA) and the ESO's European Extremely Large Telescope (E-ELT), though our concerns were eased by the recent funding announcements. This is an issue we shall keep under review and expect to return to later in the Parliament.**

3 Other funding issues

51. Setting aside the impact on current and future astronomical facilities, a number of other issues related to the STFC's budget settlement and planned funding for astronomy and particle physics over the next four years were raised during our inquiry. The following chapter outlines concerns that were raised to us related to capital funding and how and where it will be spent, particularly in relation to instrumentation research and development (R&D) and future particle accelerator technologies and the impact on the UK's existing infrastructure. The impact of budget reductions on the UK's international reputation and the diversity of the STFC's programme are also discussed.

STFC grants

52. First we will look at a problem encapsulated by Professor Stephen Hawking, Director of Research at the University of Cambridge's Centre for Theoretical Cosmology, when he noted in his submission to us: "It has been said that not all research and development comes from our Universities, but that all the researchers do".[74]

53. In its delivery plan for the next four years, the STFC has stated that it "will maintain resource spending on grants and keep studentship numbers constant, and will transition all our grant support to a new consolidated grants mechanism".[75] Appendix B to the plan indicates resource spending on research grants will be £69 million in 2011/12 rising to £75 million in 2014/15.[76]

54. In the past, as we have noted, there have been financial tensions in having responsibility for international science projects, large scientific facilities, and domestic grants within a single research council. The problems were highlighted in our predecessor Committee's 2009/10 report, *The impact of spending cuts on science and research*, and in paragraph 4 above.[77] Stability in funding for research grants has now been promised with the allocation of separate STFC budgets for its international subscriptions distinct from its core programme. This should put an end to past problems where the STFC grant provision was seen as a resource that could be raided to fund shortfalls in the STFC's international commitments.[78]

55. Nevertheless, there still remains a strategic tension between investing in individuals while, at the same time, ensuring those individuals have access to world-class facilities. The argument whether people or facilities should be prioritised in terms of investment is clearly a complex one that will be revisited if and when science funding increases. As Dr. Maggie Aderin-Pocock, Space Scientist at Astrium Ltd and Science Innovation Ltd, said to us, "I don't think you can ignore facilities, but at the same time you do need the inspiration of

[74] Ev w27, para 1

[75] STFC, *STFC Delivery Plan 2011/12-2014/15*, December 2010, p 1

[76] Table 2 at paragraph 13 above shows future STFC budgets for studentships and fellowships in astronomy and particle physics.

[77] HC 335-I (2009–10), paras 44–52

[78] Q 95 [Professor Bode]

good teaching. They go hand in hand. I don't think you can put a particular emphasis on one and not the other".[79] However, it was put to us in oral evidence that the STFC could, and should, place more emphasis on the resources available to grant funding both now and in the future.[80] Indeed, in response, Professor Keith Mason, Chief Executive of the STFC, affirmed that:

> we need to get the case across that we need to invest in talent. That is what is going to keep this country healthy in the future and we are a prime source of that talent. [I], for one, will certainly be promoting the case, as the economy improves, that we need to see this [research grants] as an excellent place to make additional investment.[81]

56. **We welcome the STFC's commitment to maintain its resource spending on research grants over the next four years. We also commend the high priority and value the STFC places on investment in researchers.**

A UK brain drain?

57. Looking forward to the next four years, we received evidence that past reductions in the number of grants awarded mean the UK is starting from a lower base than it should, which risks losing some of the UK's best young scientists to overseas countries.[82] The submission from the Far Universe Advisory Panel and the Near Universe Advisory Panel, two of five standing advisory panels which report to STFC's Science Committee for Particle Physics, Astronomy and Nuclear Physics, said that past reductions in the STFC's research grants had already resulted in many of the brightest students looking abroad to continue their careers.[83] Such concern that past and future funding constraints may have long-term impacts on the UK's reputation and ability to attract and retain the world's best scientists were echoed in oral evidence by Professor Dame Jocelyn Bell Burnell, President of the Institute of Physics,84 and perhaps most significantly, by the young scientists we spoke to. Anna Barth from Camden School for Girls said:

> One thing that made me a little bit nervous, and I don't know what could be done about it, is that, at Harvard, UCL and even with the science teachers I have now, a lot of their time is spent trying to work out where they are going to get funding from for different projects and getting grants and less time actually doing science. That doesn't seem too appealing.[85]

58. Hillary Lamb from Stroud High Schools believed that pursuing a career in a theoretical subject such as astronomy or particle physics was particularly difficult in Britain and an area "[one] might have to go over to Europe to do".[86] As Jim Al-Khalili, Professor of

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[79] Q 28

[80] Q 95 [Professor Bode and Professor Peacock]

[81] Qq 143–144

[82] Ev w26, paras 3–5 [Far Universe Advisory Panel (FUAP) and Near Universe Advisory Panel (NUAP)]

[83] Ev w26, paras 4–5

[84] Q 55

[85] Q 17

[86] As above

Physics and Public Engagement in Science at the University of Surrey, said to us, such perceptions are not surprising given recent and future funding constraints:

> If, at the moment, they are hearing the stories that research grants are squeezed, there aren't the post-doc positions at universities in particular areas, and, "If you want to do this, you are going to have to go abroad", of course, it is going to turn them away, even if they are well aware of a possible career path in science.[87]

Post-doctoral research positions

59. Evidence to the inquiry highlighted a particular problem with Post-Doctoral Research Assistant (PDRA) positions where the number of such positions has fallen by around half over the last decade.[88] In the case of astronomy, Professor John Peacock, Head of the University of Edinburgh's Institute for Astronomy, said that 56 new PDRA positions were awarded in the most recent STFC grant round compared with over 100 in 2005.[89] Although the STFC delivery plan commits to maintaining studentship and fellowship funding,[90] there appears to be no commitment to correct this historical decline in PDRAs. The delivery plan does state that the STFC intends to implement a new Studentship Enhancement Programme (STEP) which will provide 15 awards per year to students "in the first stages of their postdoctoral research careers",[91] but funding for this will be redirected from elsewhere in the STFC's programme.[92] The STFC acknowledged to us that:

> In terms of the number of postdoctoral researchers, yes, it has declined [and] it is magnified by the fact that we have such a large fraction of long-term commitments that are beyond our immediate control in the short term [i.e. international subscriptions]. So the postdoc numbers are part of this little amount of flexibility we have and, clearly, they suffer much more proportionally.[93]

60. Professor Robert Kennicutt, Director of the Institute of Astronomy at the University of Cambridge, told us that the full impact of past reductions in the number of postdoctoral positions is yet to be realised. However, he warned that if the situation persisted, the "best and brightest" would begin to look to fields outside of particle physics and astronomy[94] and that:

> The worry is that the Stephen Hawkings of the future, who are coming up as undergraduates, will move away from the subject, from their chosen research field, in the end, if they fear there is not a job for them. That is the concern.[95]

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[87] Q 38

[88] Q 93 [Professor Peacock, Professor Kennicutt and Professor Bode]; see also: Ev w25, para 17 [Professor Paul Crowther]; and Ev 99, para 4 [Professor John Peacock]

[89] Ev 99, para 4

[90] STFC, *STFC Delivery Plan 2011/12–2014/15*, December 2010, para 1.5

[91] STFC, *STFC Delivery Plan 2011/12–2014/15*, December 2010, para 2.1.2

[92] STFC, *STFC Delivery Plan 2011/12–2014/15*, December 2010, p 2

[93] Q 144

[94] Q 93

[95] Q 94

61. Professor Phil Allport, Head of Particle Physics at the University of Liverpool, highlighted the findings of a survey of scientists working at CERN who were funded by the STFC when studying for their PhDs.[96] While the survey was not statistically rigorous, it indicated that of those who had gained their doctorates since 2007, two-thirds had been made job offers outside the UK. This compared with a quarter of those who had gained their PhDs prior to 2007. Professor Allport said:

> The anecdotes are that of this year's crop, almost everybody who is staying in the field is doing so by taking posts outside the UK. That does feed back into people's expectations. Certainly, in the last round of student interviewing that I was involved in for PhDs, a number of people were expressing concerns about the prospects for careers at the end of the process.[97]

62. **We would be concerned if the budget for postdoctoral research grants was still seen as a resource that could be raided to fulfil shortfalls elsewhere. We conclude that this would be unacceptable. If the UK is to continue to attract, train and retain the very best scientists, and reap the future economic and social rewards that they will inevitably bring, the STFC must invest in researchers at every stage of their career. Any gaps or instability in funding during a scientist's career path risk losing the next generation of UK astronomers and particle physicists to other countries, disciplines and careers. We welcome the introduction of the STFC's new STEP awards for postdoctoral students, but we are concerned that the money used to fund these awards is simply being redirected from elsewhere in the STFC's programme. We recommend that the STFC now make a commitment to address over the next four years the recent decline in Post-Doctoral Research Assistant positions that it funds.**

63. **We also recommend that the STFC carry out detailed research into the post-doctoral geographic and work destinations of the researchers that it funds. We would expect the STFC to report on this in its 2012/13 annual report.**

Capital funding and R&D

64. Another key area of concern in the evidence we received was the impact of the STFC's reduced capital settlement on the UK's existing scientific infrastructure and capital intensive R&D. The University of Manchester said:

> Capital funding pays for equipment and some new projects, and its reduction will greatly affect instrumentation groups, as well as groups with high computing demands. Future projects in all areas, including Nuclear and Particle Physics, will be difficult to fund for STFC, and this will affect instrumentation work in all three areas of STFC science, hitting severely the international competitiveness of the UK.[98]

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[96] The results of the *Physic Career Survey* are provided at: hep.ph.liv.ac.uk/~laycock/PhysicsCareersSurvey/Results.html. As Professor Allport acknowledged in his written evidence (Ev 104), the survey is biased in that it mainly addresses those who are still employed in the field, predominantly has responses from those working at CERN, and reflects the view of those willing to take the time to complete the survey.

[97] Q 92

[98] Ev w38, para 2

65. Professor Kennicutt believed that, should there be an extended period of reduced funding, the UK would "suffer a permanent loss of leadership and skilled scientists in astronomical instrumentation".[99]

Capital grants to universities

66. Although, as already noted, *resource* research grant funding will be maintained over the next four years, the STFC delivery plan indicates *capital* grants to Higher Education Institutions will fall (see Table 3 below).[100] While the majority of capital funding to universities comes from the higher education funding councils[101] to support infrastructure and running costs, research councils can provide capital funding for specific research and programmes.

Table 3: STFC capital grants to Higher Education Institutions
£ million

2010/11	2011/12	2012/13	2013/14	2014/15
2.7 (a)	2.2	1.0	1.0	1.0

Note: (a) Based on provisional figures from Science Programmes Office (SPO) Exploitation Grants.

Sources: APP 33a, Science and Technology Facilities Council
STFC, Delivery Plan 2010/11 to 2014/15, December 2010, p25

67. The STFC's written submission to this inquiry stated that "the reduced capital available will potentially have impacts on [funding] for equipment within University grants".[102] In evidence to us, the STFC expressed "worry" at the reduction.[103] It explained that this category of capital was "mostly concerned with small equipment, computers and supportive equipment for general research" and noted that such grants in 2009/10 had stood at £4 million.[104] This means that the rate of reduction is even steeper than that indicated in Table 3 above, with the level from 2012/13 being just a quarter of the equivalent sum three years earlier.

68. Professor Allport said that it might be difficult for individual university groups, who had in the past used these grants to develop, for example, new detectors for facilities such as CERN, to find equivalent funding from other sources, such as the EU, because these bodies considered that this area of R&D should attract core (i.e. national government) funding.[105] He explained the effect of the reduction in funding:

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[99] Ev 43, para 1

[100] STFC, *Delivery Plan 2010/11 to 2014/15*, December 2010, Appendix C

[101] The councils are: the Higher Education Funding Council for England; the Scottish Funding Council; and the Higher Education Funding Council for Wales; in Northern Ireland the Department for Employment and Learning funds universities.

[102] Ev 51, para 5

[103] Q 146

[104] As above

[105] Q 98

> My concern is that the ability within the universities to [develop] instrumentation, to take on students involved with that instrumentation, and even to train undergraduates with that instrumentation, will be impacted by these sorts of capital cuts. It will not only take the students away from having that contact with cutting-edge technology, which is vital to the training that we should be delivering, but the universities themselves are under pressure to deliver on an impact agenda, which becomes increasingly more difficult if we don't have the in-house capabilities to be developing cutting-edge technologies. It is a double-edged sword in that respect.[106]

Professor Steve Rawlings, from Oxford University, pointed out to us that these capital reductions would also impact upon the work carried out in universities to follow-up and analyse scientific observations:

> For example, our theoretical colleagues require high performance computing. That is also counted as a capital expenditure. Of course, without the theoretical part to add to the observational part, we are not doing our full job.[107]

69. **We are concerned that the reduction in STFC capital grants available to universities over the next four years will mean that vital work in the field of instrumentation R&D, as well as the essential support and follow-up work that requires investment in computing capacity and other supportive equipment, will be neglected. We conclude that the consequence will be a loss in the UK's prominence in these areas.**

Accelerator Research and Development

70. The STFC's submission also stated that reductions in its capital allocations would:

> potentially have impacts on programmes such as accelerator research and development. [In this area] capital spending will have to be reduced based on the current funding allocation".[108]

71. Some staff at the STFC's Daresbury laboratory expressed concerns that the capital settlement would mean that the future of a number of projects at the Daresbury site might be under threat, such as the next accelerator based light source prototype machine, ALICE, the EMMA accelerator,[109] and the proposed accelerator research centre.[110] Appendix D of the STFC's delivery plan shows funding for accelerator R&D reducing from £7.04 million in 2011/12 to £6.59 million in 2014/15, although the same table also details separate funding for the accelerator centre of £3.82 million in each of the next four years.[111]

72. Professor Mason said that the STFC was currently considering the best way to direct its funds for accelerator R&D and that he hoped there would be "clarity on the direction

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[106] Q 98

[107] Q 97

[108] Ev 51, para 5

[109] The future of ALICE and EMMA has been in question since the time of the last spending review in 2007. See, HC 215–I (2007–08), para 62.

[110] Ev w12, [Daresbury Laboratory Section of Prospect]

[111] STFC, *Delivery Plan 2010/11 to 2014/15*, December 2010, Appendix D

forward within the next couple of months".[112] We welcome the Government's announcement in the 2011 Budget to invest an additional £100 million in 2011/12 in capital development for scientific facilities.[113] This will mean an additional £20 million in capital funding for the STFC's Daresbury and Harwell sites.[114]

73. More widely, concerns have been raised about the UK's role in the future development of particle accelerators for the post-Large Hadron Collider era (i.e., beyond the next 15–20 years).[115] The STFC decided at the time of the last spending review in 2007 to withdraw UK funding from the International Linear Collider project,[116] and during our visit to CERN in February we learned that overall funding for the Compact Linear Collider, a study for a future electron-positron collider, was being reduced.

74. Professor Andrei Seryi, Director of the John Adams Institute for Accelerator Science, considered that the capital settlement would have an impact on the UK's involvement in the next generation of particle accelerators:

> From the point of view of accelerator science [we] are trying to develop various methods of how to make future accelerators and colliders better, smaller and less expensive. For this, we need research developments for attracting students and capital funds to make small test facilities. All these are essential components. I really worry about our ability to contribute significantly to these future projects which are aimed at discovery science, like high energy physics [but] also I worry about our ability to contribute noticeably to applications of accelerators which are beyond discovery science, which are applications for energy security, nuclear energy security, health, engineering and to developing all the facilities which will be needed everywhere in addition to discovery science.[117]

75. During our visit to CERN we were struck by the wide-range of applications and benefits this area of science generates, particularly in the fields of medicine and engineering.[118] However, it was notable that the scientists and officials we met could not yet determine where the future of such colliders lay. Professor Allport said there were lots of directions in which future accelerator science could go:

> There are directions which go in terms of the Linear Collider. There are directions which go in terms of the ep [Electron Positron] collider. There are directions in terms of trying [to] double the energy of the LHC in the current ring. Then there are a large number of other facilities around the world which tend to concentrate on doing very high statistics experiments and, therefore, require extremely high

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[112] Q 139

[113] HM Treasury, *Budget 2011*, March 2011, HC 836, para 1.93

[114] "More than £20M capital funding for STFC science announced by Chancellor", STFC Press Release, 23 March 2011

[115] See, for example: Ev 45, para 3 [Institute of Physics].

[116] STFC, *Delivery Plan 2008-2011*, para 2.1

[117] Q 100

[118] For example, the application of Hadron therapy in the field of cancer treatment

intensity beams for neutrinos, muon storage rings, e+ or e- for B-factories and so on.[119]

76. **Important decisions will shortly have to be made about the allocation of relatively scarce resources for accelerator R&D over the next four years. These decisions will determine whether the UK has a significant part to play in this field for decades to come. Given the widespread applications and benefits of this area of science, the STFC must ensure it makes these decisions on the basis of a long-term, scientifically-informed, strategic vision that ensures the UK stays at the forefront of activities in developing new technologies.**

STFC's "in-house" focus

77. The STFC delivery plan includes a proposal to "focus the capabilities of STFC's in-house researchers, especially in astronomy, particle physics and nuclear physics, on technology, instrumentation and detector development, allowing university scientists to concentrate on research".[120] This proposal was the subject of conflicting interpretations during our inquiry. A number of submissions understood this to be a reduction in support to university R&D which would impact upon the UK's ability to develop and lead in the field of innovative new technologies. The Institute of Physics said that within the field of particle physics, especially in relation to the Large Hadron Collider experiments, much of the recent technology, instrumentation and detector development had been led by university groups:

> Detectors in particle physics (and astronomy) can only be built successfully in close contact with those who use the data and understand the nature of the technical challenges and the reasons for the demanding technical requirements; this is how the rest of the world operates. Any attempt to make unilateral changes to this method of working would undermine UK leadership and innovation in detector technology, and may make it harder for UK industry to compete successfully for contracts.[121]

78. The STFC challenged the suggestion that the proposal in the STFC delivery plan represented a move away from the current method of working. Professor Mason said to us that:

> What we are trying to say there is, essentially, a re-statement of our existing position and the existing mission of our national laboratories, which is that they are there to support the scientific communities, and in particular in these capital intensive areas of building large detectors—not doing the detector R and D but building large instrumentation. What we were trying to capture there was not so much that we were going to prevent the universities from doing technology development, but we were going to encourage our in-house researchers not to compete with the universities in terms of scientific research and to concentrate on their core mission, which is to support the university communities in their endeavours. [I] would re-

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[119] Q 100

[120] STFC, *Delivery Plan 2010/11 to 2014/15*, December 2010, para 4.1.3

[121] Ev 46, para 8

> emphasise once and for all that we are not intending, nor would it be sensible, to restrict the university community from doing technical R and D and from doing blue-skies research of a technical kind. That would just be totally counter-productive. I hope I can lay that to rest once and for all.[122]

> [There] is no sub-text here. There is no subterfuge. There is no hidden plan at all. This is exactly as it seems, which is just re-stating where the national laboratories fit into the overall landscape of scientific research in the UK.[123]

79. Nevertheless, concerns persist. In response to Professor Mason's remarks, Professor Allport said in a supplementary memorandum:

> My concern was not where R&D is to be carried out [but] the actual construction work. [Future] construction effort will also have to be at institutions which are fully engaged in the physics exploitation and this is the model that applies to those aspects carried out both in the universities and in the national laboratories.[124]

80. **We welcome the STFC's clarification that proposals in its delivery plan will not impact on technical R&D work carried out in universities. However, the STFC must ensure that what it says is a restatement of the current working relationship between university groups and the STFC's own laboratories does not result in the construction capabilities and the expertise within UK universities being underused in favour of focusing future construction activities at the STFC's own laboratories.**

Existing infrastructure

81. Reductions to *capital* funding will also have implications on the maintenance and upgrading of existing scientific facilities in the UK. As indicated in Table 1 at paragraph 9, the STFC's capital budget will fall by 24% over the next four years. The Institute of Physics said that, while capital reductions could be coped with in the short-term, if maintained for longer:

> the decay in infrastructure will cause considerable harm to UK science. In relative terms, the UK will very rapidly fall back compared with its international competitor nations where investment levels are greater because they recognise the long-term value of science to their economies.[125]

As we were told by Professor Peacock, "you can get away with it for a while and you hope that nothing breaks, but it will eventually".[126]

82. BIS has stated that the capital allocations are "indicative" for the three years from 2012/13 to 2014/15.[127] In January, Professor Alan Thorpe, Chair of the Research Councils

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[122] Q 135

[123] Q 142

[124] Ev 104

[125] Ev 45, para 1

[126] Q 99

[127] BIS, *The allocation of science and research funding 2011/12 to 2014/15*, December 2010, p 19

UK Executive Group and Chief Executive of the Natural Environment Research Council, stated that he was "optimistic" that there would be an opportunity for these indicative allocations "to go up in the future".[128]

83. **While in the short-term the impact of capital reductions on existing facilities may be manageable, the STFC must ensure that, if opportunities for increased capital investment arise during the next four years and beyond, it prioritises maintaining the cutting-edge capabilities of the UK's existing scientific infrastructure. To enable the STFC to plan properly for the next four years, we urge the Government to make clear its allocations to Research Councils for capital spending beyond 2011/12 as soon as possible.**

Concentration of funding

84. An issue that emerged during oral evidence was the apparent shift by the STFC in recent years towards narrowing its financial support in fewer areas and projects. As noted in paragraph 75, in the case of particle physics, scientists are unclear about the future scientific direction. Professor Bell Burnell said that:

> the narrowing of the programme [that] is going to happen, or is planned to happen, as a consequence of the cuts means that we have only a single focus. It is very dangerous to have all your eggs in one basket, and that is effectively what we are going to be doing. It does not [provide] a healthy diversity that will allow for future developments.[129]

85. The figures appear to bear out the concentration of resources. In 2010/11 the STFC's main CERN subscription accounted for over 60% of the £158 million spent on particle physics. On astronomy, there has been a shift by the STFC towards focusing its resources through the ESO. Professor Allport suggested that problems in concentration resulted from the way decisions were taken following the STFC's 2009 prioritisation exercise, with an apparent correlation between those projects that were of high cost being given high priority, and those of low cost assigned low priority.[130] He said that there was, however, scope for a more nuanced approach to be taken:

> If one were to take a budget and say, "How do I best fit a programme into it?", then one could do the high priority, high cost, but also try and get the Alpha 2s and 3s—Alpha 2 or Alpha 3 means that this is excellent international science—and try and get those low cost projects into the envelope so that you have a wider portfolio. This requires a different style of managing the science within each science area. It is more subtle than taking a priority listing and then saying, "Everything less than Alpha 3 gets cut." There is room, even within a constrained budget, for trying to broaden the programme, but it requires some different methodology to achieve that.[131]

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[128] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 90

[129] Q 55

[130] Q 104

[131] As above

86. **We recognise the significance of astronomy and particle physics to a wide range of important scientific developments. We conclude it is therefore important that the STFC ensures current and future investment decisions protect the breadth of this work and ensure the UK is at the forefront of future developments in astronomy and particle physics.**

The UK's international reputation

87. In their evidence put to us in January, the Research Council chief executives highlighted the importance of international collaboration as a means of offsetting future funding reductions.[132] However, past decisions by the STFC on international projects, such as withdrawal from the International Linear Collider programme,[133] and the aborted attempt by the STFC to reduce its involvement in Gemini in 2007/08, which resulted in temporary expulsion of the UK from the project before the STFC reversed its decision,[134] mean the UK has not always been seen as a reliable international partner. Further withdrawals are planned, such as those announced following the 2009 prioritisation exercise[135] and there seems to us a risk that, given future funding constraints, more will be announced. The submission from Professor Patrick Roche, Head of Astrophysics at Oxford University, highlighted the problem:

> the hard-won UK reputation in astronomy may be undermined by the reductions in funding at a time when many of our competitors are maintaining or even increasing their funding.[136]

88. The Institute of Physics said that the UK was already "viewed as an unreliable partner",[137] and Professor Hawking took the view that the "erosion of funding for astronomy and particle physics in recent years has harmed the position and reputation of the UK in the international scientific community".[138] Sir Adrian Smith, Director General of Knowledge and Innovation at BIS, however, took a different view:

> In general terms, broadly, there is no mood out there that the UK is an unreliable partner. There will be specific projects that one might have wanted to be involved in that cannot be done. That is all part of the prioritisation project. But any kind of exaggeration that the UK is suddenly not a major international player or that our reputation is not respected is nonsense.[139]

89. **We are concerned that past and future decisions to withdraw the UK from internationally collaborative projects and the subsequent impact on the UK's**

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[132] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Q 72

[133] STFC, *Delivery Plan 2008–2011*, para 2.1

[134] Ev w33, para 3.5 [Dr Bryn Jones]; as noted in paragraphs 5 to 7, following the 2009 prioritisation exercise the STFC subsequently announced in December 2009 that it would be withdrawing from Gemini fully in 2012.

[135] For more information see paragraph 6 and Annex 2.

[136] Ev 104, para 11

[137] Ev 45, para 6; see also Ev 40, para 16 [Royal Astronomical Society].

[138] Ev w27, para 2

[139] Q 140

international reputation may affect the potential future gains from such collaboration that the STFC, and other research councils, expect to achieve. Indeed, there appears to us to be a danger that the UK's track-record may hinder its ability to join, and be seen as a leader in, future collaborations. The assessment by Sir Adrian Smith, Director General for Knowledge and Innovation at BIS, is that the UK is not seen as an unreliable international partner. We conclude, however, that this does not fit with the assessment of the Institute of Physics and Professor Stephen Hawking who, in our view, are in a better position to make a judgement on this important matter.

4 STFC engagement with researchers

90. In 2008, the former Innovation, Universities, Science and Skills Committee said that the common theme linking many of the problems following the STFC formation in 2007, from reductions in grant lines and specific projects to the impact of its budget on the STFC's own sites, had been poor communication.[140] The Committee concluded that:

> STFC's communications are inadequate, particularly its internal communications, which are deficient both in terms of top down communication (for example, alerting staff to proposed changes) and bottom up communication (for example, engaging the community over decisions). We recommend that STFC pursue urgently the appointment of a permanent Communications Director with appropriate skills and experience.[141]

91. Following this recommendation the STFC appointed a communications director, and we received a range of submissions to this inquiry acknowledging that the STFC had made significant efforts to increase engagement with researchers and academia in recent years.[142] This has included the formation of independent panels to inform STFC policy (such as the Ground-Based Facilities Review Panel set up during the 2009 prioritisation exercise)[143] and the STFC's participation at events hosted and convened by learned societies prior to, and after, the spending review and science budget allocations. Professor Dame Jocelyn Bell Burnell, President of the Institute of Physics, described the relationship in the past as "atrocious" but said that it was "considerably better now".[144] Indeed, when we asked Professor Bell Burnell "If atrocious is zero and perfect relationships are 10, where is the relationship at now?", she replied "Six or seven".[145]

92. **We note the President of the Institute of Physics' comments on recent improvement made by the STFC in its engagement with researchers. Some lessons from earlier failures in communication and engagement have been learned but there is still a large amount of room for improvement.**

STFC senior management and structure

93. Tensions still exist, particularly in relation to STFC senior management and the science advocacy role it is perceived to play.[146] Evidence of continued problems was presented to us in the terms used to express the concerns about the comments made by the STFC to the Committee in January on the planned over investment in astronomy and associated withdrawal from some facilities, which we discussed in paragraphs 22 to 34. The Royal Astronomical Society described the comments as "misleading" and requiring

[140] HC 215–I (2007–08), para 86

[141] HC 215–I (2007–08), para 87

[142] See, for example: Ev 41, para 24 [Royal Astronomical Society]; Ev 47, para 13 [Institute of Physics].

[143] See, paragraph 5.

[144] Q 51

[145] Q 57

[146] Ev 41, para 28 [Royal Astronomical Society]

clarification,[147] while the University of Manchester did not "recognise" the statements.[148] The wider long-standing tensions were noted by Professor Robert Kennicutt, Director of the Institute of Astronomy at the University of Cambridge:

> I regret to say that a disturbing disengagement—sometimes bordering on an adversarial relationship—has developed between the STFC Council and its research community. [The] STFC Council itself often appears to be out of touch, most of all its Chief Executive. [The] financial pressures present since the STFC was formed have not helped; but the level of disengagement and acrimony that I have seen here is unlike anything I have observed in 30 years of professional life in the US and UK. [I] believe its origins are complex and include irrationalities in the structure of STFC when it was formed, insufficient core scientific representation on its Council, and a leadership vacuum from its Chief Executive.[149]

94. We also received a number of representations concerning the composition of the STFC Council and the need to increase its relatively low number of academic members compared with other research councils. Professor Paul Crowther, from the University of Sheffield, indicated that four out of twelve members on the STFC council were "currently" academics,[150] compared with, for example, eight out of 16 at the Biotechnology and Biological Sciences Research Council.[151] However, Sir Adrian Smith said in oral evidence that including the Chair, Professor Michael Sterling, "there are six members on the [STFC] council who I would view as scientists", which reflects a ratio "about the same" as other research councils.[152] The Government-commissioned 2008 *Review of UK Physics* (the Wakeham Review) recommended "that the membership of the STFC's Council be broadened to include more of the stakeholders in the science activity at the highest level, and to redress the balance between executive presence and non-executive oversight",[153] and we note that some, such as Professor George Efstathiou, Director of the Kavli Institute for Cosmology at the University of Cambridge, remain unconvinced that this had been fully achieved.[154] In a supplementary memorandum Professor Efstathiou said:

> STFC has only one research academic in particle physics (James Sterling) and only one research academic in astronomy (Martin Barstow). I cannot see how Adrian Smith can say that the composition of STFC is similar to that of other research councils.[155]

95. **We conclude that one simple step towards winning back the trust of researchers would be to ensure that researchers and academia are sufficiently involved in the high-level decision making in the STFC on a consistent basis. We recommend that the STFC**

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[147] Ev 41, para 28

[148] Ev w39, para 14

[149] Ev 44, para 3

[150] The other members of the Council are STFC staff and representatives from industry and university administrations.

[151] Ev w24, para 14

[152] Qq 166, 169

[153] RCUK, *Review of UK Physics*, October 2008, para 8.8

[154] Ev w2, para 5

[155] Ev w3

make a permanent commitment to ensure that at least 50% of STFC Council members are practicing academics and include at least one individual from each of the core scientific fields for which the STFC is responsible—astronomy, particle physics and nuclear physics.

Future communication and the next STFC Chief Executive

96. One of the common themes running through this report and the evidence we received was the adequacy of communication between the STFC and researchers. That continuing difficulties persist between researchers and STFC senior management was clearly shown to us. Two issues during our inquiry epitomised these problems: first, the dispute over the long-term strategy for astronomy dating back to accession to the ESO;[156] and, second, the apparent misunderstanding over the STFC's plans for research on technology, instrumentation and detector development.[157] On the latter, although the STFC was keen to emphasise to us that efforts had been made following the publication of the delivery plan to clarify the STFC's position,[158] the evident ongoing concern in oral and written evidence on this issue indicates enough was not done. This could, and should, have been cleared up far sooner following the publication of the STFC's delivery plan. When we asked Professor Mason:

> should [the STFC] really leave it to a public session of the Science and Technology Committee of the House of Commons to communicate in that way? Shouldn't you be communicating directly and clarifying?

He replied that the STFC had "done so", and cited meetings of the Institute of Physics and Royal Astronomical Society at which the STFC's director of science programmes had made the STFC's position "absolutely crystal clear".[159]

97. The current STFC Chief Executive comes to the end of his term in March 2012.[160] Professor Mike Bode, Director of the Astrophysics Research Institute at Liverpool John Moores University, set out his assessment of what the post of STFC Chief Executive demands:

> There is no doubt that the chief exec's job is an incredibly tough and demanding one. The STFC is an exceptionally complex organisation. [There] is a perception in the community that there has been a disconnect between [other senior STFC staff], who have been interacting with the community, and the chief executive. The perception is [...] that the chief executive has been more upward facing into Government, which is obviously a vital role of the chief exec, but he has not been pushing the basic science

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[156] As discussed in paragraphs 22 to 34.

[157] As discussed in paragraphs 77 to 80.

[158] Q 142

[159] As above

[160] STFC Council, *Terms of reference for Council working group*, 28 July 2010, STFC website: www.stfc.ac.uk/About%20STFC/19176.aspx

as much as the other parts of the STFC remit, certainly not as much as the community would have wanted.[161]

98. Professor Kennicutt highlighted a recent report by an STFC working group which defined the qualities, skills and experiences required in a new STFC Chief Executive.[162] We commend the mandatory requirements set out in this document, and in particular that the next Chief Executive must:

a) have a strong and respected STEM background and qualification (at least to PhD level), or similar (e.g. in the biomedical sector) provided candidates can demonstrate an appreciation and understanding of the scale and complexity of the STFC's science and research; and

b) command the respect of the academic communities and be seen as a champion of the STFC's research base.[163]

99. **The next STFC Chief Executive must make it clear from the outset his or her commitment to work with researchers and academics, and act as an advocate for all of the science disciplines covered by the STFC. We will continue to scrutinise the actions of the STFC throughout this Parliament, and will invite the next STFC Chief Executive to appear before us at the earliest available opportunity.**

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[161] Q 89

[162] As above

[163] STFC Council, *Summary of STFC Council Working Group*, November 2010, para 3

5 Inspiring the next generation of scientists

100. Professor Stephen Hawking, Director of Research at the University of Cambridge's Centre for Theoretical Cosmology, noted that "without strong support for subjects like particle physics and astronomy we will suffer the economic and cultural consequences of a lack of students in the physical sciences".[164] This chimed with the oral evidence of Professor Keith Mason, Chief Executive of the STFC, who said to us that researchers in areas such as astronomy and particle physics contributed "hugely to our economic health, our development as a society and in many other ways [we] need more of them".[165] If the UK's supply of astronomers and particle physicist is to be ensured for future generations to come, and the benefits they will bring, it is important that every effort is made to inspire young people to study science. There are a variety of ways in which we believe this can be done more effectively.

The role of current researchers and scientists

101. In our view, effective public engagement with astronomy and particle physics is currently extremely high. The widespread media exposure of events such as the launch of the Large Hadron Collider in 2008, and the popularity of television programmes such as *Stargazing Live* (three days of live televised coverage to coincide with a number of astronomical events in January 2011) and the two recent BBC series presented by Professor Brian Cox on the solar system and universe have brought astronomy and particle physics directly into the nation's consciousness. The Institute of Physics said the increased exposure of physics and astronomy in the media in recent years was having a positive impact on inspiring future generations of scientists:

> Outreach in particle physics, astroparticle physics, astronomy and nuclear physics has never been in better health, spearheaded by Professors Brian Cox and Jim Al-Khalili but ably supported by a very large number of other scientists. Substantial media coverage [backs] up the very extensive work in schools—almost every day a STFC funded scientist is in a school somewhere in the UK enthusing young people to study physics and science in general.[166]

102. We asked Dr Maggie Aderin-Pocock and Professor Jim Al-Khalili about the role of the scientific community in improving science outreach and engagement in order to inspire the next generation of scientists. They both believed the current high level of outreach and public engagement needed to be exploited through ongoing promotion of astronomy and physics by researchers and scientist.[167] As Dr Aderin-Pocock said, "we [scientists] can't rest on our laurels".[168]

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[164] Ev w28, para 3

[165] Q 143

[166] Ev 47, para 15

[167] Q 31

[168] As above

Defined outreach activities

103. The STFC's Science in Society Fellowships allow experienced researchers to spend the equivalent of one day a week over the course of a year pursuing public engagement work.[169] Some had concerns, however, about the future ability of researchers and scientists to carry out outreach as resources fall. For example, the Daresbury Laboratory Section of Prospect said:

> One of the first casualties as resources fall is outreach because it is a 'soft option'. Outreach is generally 'tagged on' to a person's responsibilities, and as resources dwindle and pressure increases to get more things done more quickly, the 'day job' has to take priority and secondary duties such as outreach fall by the wayside. Consequently, a feedback loop is created whereby the next generation of scientists are not being drawn out of the university population, so again reducing our ability to compete with the rest of the world. STFC's staff work in some of the key areas that fuel young people's interest in science [and] have a vital role to play in inspiring an interest in science and involving young people in it as they progress through education.[170]

104. Professor Al-Khalili suggested to us that there should be specific provision within the requirements for some grant applications to allow individual researchers more time to spend on outreach activities:

> PPARC, the predecessor of STFC, had as part of their grant applications a provision that they had to spend a certain fraction [on] outreach and public engagement. In practice, what tended to happen, particularly for large departments, was that the grant money for public engagement was pooled into one pot and then the department had someone who was good at outreach and public engagement, and they were doing it on their behalf.[171]

In oral evidence, Professor Mason indicated that, within the STFC's new consolidated grants system, university researchers were being encouraged to conduct a proportionate amount of public engagement.[172]

105. **We conclude that outreach is essential. We believe there is scope for a more dedicated and defined outreach role for some researchers and institutions funded by the STFC. We recommend that the STFC investigate opportunities within specific grant applications of university groups and institutions to allocate defined, ring-fenced funding for the employment of active researchers to carry out dedicated outreach and public engagement activities as an integral part of their role.**

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[169] Ev 42, para 36 [Royal Astronomical Society]

[170] Ev w13, para 4

[171] Q 32

[172] Q 153

Experiencing science

106. Ensuring linkage between the education system, young aspiring scientists and scientific research has emerged as an important theme during our inquiry. This was evident during the evidence session we held with a group of young astronomers and physicists currently studying for their A Levels. What was clear to us was their enthusiasm to advance their learning in the future and the important role that their education, teachers and experiences to date had played. The students emphasised the availability and provision of appropriate work experience and the use of scientific facilities, such as the Liverpool telescope, which inspired their interest. Hilary Lamb from Stroud High School said:

> It is enormously important to get rid of [the] textbook approach to physics because, if students just learn physics out of a textbook all their lives, that is all they think it is. It is more important to get them doing science and get them actively involved in the things they find interesting and inspiring.[173]

107. In some cases it was simple practical experiences that inspired the students. Jessica Grainger from Saint Peter and Paul Catholic College told us how the STFC had bought in lunar samples to her school,[174] while Jack Bliss from Allerton Grange School described the first time he was made to think about science and its implications:

> I was in a car and I saw the glare bouncing off the back of a car in front of me. It was the first time I really understood what that glare was, like photons travelling all the way from the Sun, a straight shot, eight minutes' old light, bouncing off the car and into my eye. It is humbling to think that it had come all that way.[175]

108. The students also highlighted the importance of careers advice at an early age and the opportunity to shadow active researchers throughout their studies. James May from Castell Alun High School said:

> I have not looked into [careers in science] too much, but that is primarily because we have not been told very much about it. Maybe at a younger age, maybe as far as GCSE level and definitely A Level, to be able to be offered a position, like a work experience placement [and] to be able to push a little bit more to learn what you want to learn by shadowing somebody, for instance, could give you the extra help you need to follow the course and, again, further on, maybe at degree level, to shadow somebody slightly higher up, just to keep your path where you want to go.[176]

109. Jessica Grainger pointed out that many students have already decided that science was not for them by the time they reach secondary school.[177] There seems to be not only a responsibility on schools to promote careers in science but also on universities and industry who will train and employ the UK's future scientists. As Charlie Palin from Neston High School noted:

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[173] Q 23

[174] Q 1

[175] Q 12

[176] Q 17

[177] Q 20

> It is vital that organisations such as [the UK Space Agency and Astrium] engage with students of today and show them that there are paths to take and things to go on to.[178]

110. The importance and impact of bringing students closer to, and experiencing, science first hand is clear. As we have noted, the STFC already has a well developed programme of outreach which provides hands-on learning to schools through its own facilities.[179] However, **we believe the STFC should exploit its network of strategic partners in the public sector, universities, learned societies and industry and act as a conduit in developing, coordinating and promoting a formal programme of outreach between these partner organisations and schools. The STFC's delivery plan specifically outlines plans to strengthen its strategic partnerships and we recommend that outreach be seen as a key element of work in this area.**[180]

The role of the STFC and Research Councils UK (RCUK)

111. We received evidence that the STFC already has a good record of promoting public engagement in science through its Science in Society programme[181] which has four main strategic objectives:

a) to stimulate and respond to public interest in research developments;

b) to link STFC science and technology with schools and young people to support the national STEM agenda;

c) to encourage and support researchers who engage with the STFC in their public engagement work; and

d) to capitalise on the laboratories/campuses as excellent technical sites that have delivery programmes and partnerships for regional STEM and skills activities.[182]

112. Professor Mason said to us that funding for the outreach programme would be maintained in cash terms at £1.6 million over the next four years,[183] although this will still mean real terms reductions. Evidence from the Association for Astronomy Education noted that this area of funding has already seen past reductions and in some cases schools were now competing with university groups for funding:

> the Science Centre Award Scheme has been withdrawn and the upper limit of the Small Award Scheme has been reduced to £10,000 [from £15,000]. However a Schools Grant Scheme has been added for projects up to £500. This is plainly inadequate. There is very little that can be done with such a budget other than to provide a one-off activity or buy a modest piece of equipment. While the Large

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[178] Q 19

[179] "Outreach Activities", STFC webpage: www.stfc.ac.uk/Public+and+Schools/1286.aspx

[180] STFC, *Delivery Plan 2010/11 to 2014/15*, December 2010, para 3.6

[181] For example, Ev 42, para 36 [Royal Astronomical Society] and Ev 47, para 16 [Institute of Physics]

[182] "Advisory Panel for Science in Society (APSiS)", STFC webpage: www.stfc.ac.uk/Public+and+Schools/4956.aspx

[183] Q 148

Award Scheme offers funding from £10,000 - £100,000, there is more emphasis on research, with strong links to the STFC scientific research community. This places non-university applicants for educational Large Awards funding in direct competition with research groups.[184]

113. **At a time when the public profile of astronomy and particle physics is high, we are concerned to learn that the funding made available for public engagement award schemes within the STFC's Science in Society programme has already been squeezed. The STFC must look to protect and increase this area of funding wherever possible.**

114. Professor Mason also said to us that the STFC was "working with our research council colleagues to promote public engagement at the RCUK level."[185] In its written evidence RCUK, which represents all seven research councils, highlighted its Public Engagement with Research Programme which includes a programme of teacher Continued Professional Development entitled *Bringing Cutting Edge Science into the Classroom*, and a Researchers in Residence scheme which brings early-stage researchers into schools.[186]

115. Dr Maggie Aderin-Pocock said that problems persisted more widely with the lack of joined-up working and co-ordination between government departments and research councils on work promoting science and research in the UK education system.[187] RCUK said that it currently engaged with the Department for Education, but would "value the opportunity to do more in this area [and] work more closely with partners who are delivering extra-curricular activities to encourage them to include contemporary research contexts".[188]

116. **Especially in these financially constrained times, the Department for Education and RCUK should seek to foster relationships between research councils, local education authorities and schools in order to enable research council employees, and research council funded-researchers, to carry out outreach activities on a more systematic and coordinated basis in primary and secondary education.**

The National Schools Observatory

117. A barrier to creating the necessary links between education and research is the silo mentality. Notwithstanding 30 years of governments telling us that barriers between government departments and agencies were disappearing we saw all too clearly that it continues to pervade government. The experience of the National Schools Observatory (NSO) epitomised the shortcomings still inherent in the system. The future of the NSO is currently in doubt following the decision by the STFC to withdraw funding from the Liverpool telescope from which the NSO provides schools with free access to astronomical data. The Institute of Physics said "no other telescope that falls within STFC's (or ESO's) remit provides this opportunity for schools, and it would be hard to envisage a cost-

[184] Ev w10, para 2

[185] Q 148

[186] Ev w47–48, paras 3–8

[187] Qq 43–44

[188] Ev w47, para 5

effective way for the NSO function to be delivered via an alternative route [than the Liverpool telescope]".[189]

118. In January, when we asked about the STFC's involvement in the NSO, Professor Mason described it as a "different animal", implying to us that it was outside of the STFC's responsibilities and an "education issue".[190] He also suggested that the future of the NSO was not entirely dependent on continued investment in the Liverpool telescope stating there were "other partnerships and arrangements that one could make".[191] This latter point was disputed by Professor Mike Bode, Director of the Astrophysics Research Institute at Liverpool John Moores University which owns the Liverpool telescope, who said:

> There is a symbiotic relationship between the [Liverpool telescope] and the NSO. They have grown up together and they are intimately related. The NSO relies on the functionality of the [Liverpool telescope]. [Could] the NSO programme be moved on to another telescope? Within the STFC's area, there is not another robotic, professional research telescope on an excellent site to which that could be moved.[192]

119. The STFC's submission to this inquiry emphasised that it is "primarily a research body",[193] a premise which we accept. However, the STFC does support outreach and, collectively with the other research councils, has a strategic commitment to "inspire young people to help secure and sustain a supply of future researchers to support the research base that is critical to the UK economy by encouraging engagement between young people and researchers".[194] It was suggested to us by Liverpool John Moores University that the Department for Education and its agencies sees the exploitation of research facilities through projects such as the NSO as falling within the remit of the research councils, and as a consequence such important outreach and education projects will continue to fall "between two stools".[195]

120. When we asked Professor Mason in March if he had now spoken to the Department for Education about the future of the NSO he said "No, I have not, because the Liverpool Telescope and the NSO is not owned or operated by the STFC. It is the responsibility of Liverpool John Moores University".[196] However, he said that he would be willing to support a dialogue between Liverpool John Moores University and the Department for Education, while Sir Adrian Smith also confirmed BIS would be "more than happy to join in".[197] We note again that the STFC's own delivery plan explicitly sets out its intention to strengthen its strategic partnerships, including with government departments.[198]

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[189] Ev 47, para 17

[190] Transcript of oral evidence, *Spending Review 2010*, 19 January 2011, HC618–ii, Qq 132–33

[191] Q 134

[192] Q 111

[193] Ev 53, para 30

[194] Ev w47, para 4 [Research Councils UK]

[195] Ev 95, para 22

[196] Q 116

[197] Q 117

[198] STFC, *STFC Delivery Plan 2011/12–2014/15*, December 2010, para 3.6

121. Our questions in January made it clear to the Government and the STFC that we had an interest in the future of the NSO. Despite putting officials on notice about the issue, nothing had been sorted by the time that the STFC gave evidence again to us in March. **It is unacceptable that senior civil servants have passed the buck on the future of the NSO. This 'silo mentality' which pervades government and is a clear barrier to any notion that Whitehall is becoming more 'joined-up' means relatively cost-effective educational research projects, such as the NSO, which are so important to inspiring the next generation of scientists, risk being lost. Clear mechanisms must be put in place to stop issues like this falling between ministerial, departmental, and research council responsibility.**

6 Conclusions

122. The OECD's 2010 *Innovation Strategy* stated: "it is crucial [that governments] continue to invest in future long-term sources of growth such as education, infrastructure and research [while] cutting back public investment in support of innovation may provide short-term fiscal relief, it will hit long-term growth."[199] Over the next four years funding for astronomy in the UK will see a significant reduction, while the budget for particle physics will, at best, stand still. At a time when many of the UK's international peers plan to invest more in science and innovation as part of long-term strategies to ensure economic growth, reduced budgets will impact on the UK's growth prospects, reputation and ability to stay at the forefront of developments in the fields of astronomy and particle physics. Moreover, these reductions will impair the UK's ability to attract and inspire the next generation of astronomers and particle physicists. This means how the STFC spends its budget, and its long-term strategies for beyond the next four years, will be all the more important.

123. We have concerns that the STFC is increasingly focusing its astronomy and particle physics programmes into fewer areas. By failing to encourage the healthy diversity that comes from funding a varied portfolio of programmes the UK risks losing its ability to stay at the forefront of future developments. A case in point is the UK's planned withdrawal from all Northern Hemisphere optical and ground based astronomical facilities, which may hand over UK leadership and competitive advantage in this field to international peers.

124. Finally, if the STFC is to do its job effectively, it must in the future act as a clear advocate for its science disciplines. As our inquiry has shown, there are areas where there is room for improvement. In particular, the STFC must continue to build bridges with the academics, researchers and scientists it funds. However, the wider research community also has an important role to play, and we believe that in the interest of the UK's future prominence in the fields of astronomy and particle physics it is time to move on from issues of past strategy and finance in order to concentrate on the future.

[199] OECD, *Key findings of the OECD Innovation Strategy 2010*, May 2010

Conclusions and recommendations

Reductions to the astronomy budget and past strategy

1. Given the evidence and documentation presented to us, we accept that there was a stated long-term intention to withdraw from some facilities following ESO accession. We note and welcome the clarification by the STFC that this was a financial rather than scientific strategy. (Paragraph 32)

2. However, while ESO accession required some strategic restructuring of UK investments, as set out in the 2001 PPARC papers, the strategic decision does not provide cover for all future reductions in spending on astronomy. We find it inexplicable that the planned withdrawals detailed in the 2001 PPARC papers were not incorporated into all subsequent PPARC and STFC policy documents. This would have given the UK astronomical community the opportunity to challenge this policy in more detail, particularly as it was suggested to us that more than double the savings had been made than were required to join ESO. Unfortunately, this failure by STFC to communicate is chronic and typical and is the reason why its client communities have such a low opinion of it. (Paragraph 33)

3. For the benefit of transparency, we recommend that the STFC make publicly available all PPARC and STFC council minutes and strategy documents which discuss UK spending on, and involvement in, ground-based astronomical facilities over the last ten years. (Paragraph 34)

Withdrawal from ground-based astronomical facilities

4. Withdrawal from all Northern Hemisphere ground-based optical and infrared facilities risks, in our opinion, surrendering the UK's prominence in this field to other ESO member states and depriving UK astronomers of a leading role in future discoveries and instrumentation development. It is essential that the STFC re-examine the case for retaining access to those telescope that it owns, especially in light of the relatively small amount of money that would allow continuity. We have concerns that it could be to the detriment of UK astronomy if the UK presence in all ground-based optical and infrared facilities outside of the ESO were to be lost. (Paragraph 45)

Funding of future astronomical projects

5. We welcome the recent decision to locate the SKA project office at the Jodrell Bank Observatory near Manchester. This will enable the UK to take a leading role in the ongoing development of this project, and reflects the high-regard for UK astronomy and astronomers internationally. This happy conclusion would not have been possible if the STFC had not reversed its original intention to remove funding for the e-MERLIN radio telescope at Jodrell Bank, an issue our predecessors had raised serious concerns about. (Paragraph 49)

6. We are concerned that short-term funding constraints may hinder the UK's ability to lead on the ongoing development and construction of priority astronomical projects such as the Square Kilometre Array (SKA) and the ESO's European Extremely Large Telescope (E-ELT), though our concerns were eased by the recent funding announcements. This is an issue we shall keep under review and expect to return to later in the Parliament. (Paragraph 50)

STFC grants

7. We welcome the STFC's commitment to maintain its resource spending on research grants over the next four years. We also commend the high priority and value the STFC places on investment in researchers. (Paragraph 56)

Post-doctoral research positions

8. We would be concerned if the budget for postdoctoral research grants was still seen as a resource that could be raided to fulfil shortfalls elsewhere. We conclude that this would be unacceptable. If the UK is to continue to attract, train and retain the very best scientists, and reap the future economic and social rewards that they will inevitably bring, the STFC must invest in researchers at every stage of their career. Any gaps or instability in funding during a scientist's career path risk losing the next generation of UK astronomers and particle physicists to other countries, disciplines and careers. We welcome the introduction of the STFC's new STEP awards for postdoctoral students, but we are concerned that the money used to fund these awards is simply being redirected from elsewhere in the STFC's programme. We recommend that the STFC now make a commitment to address over the next four years the recent decline in Post-Doctoral Research Assistant positions that it funds. (Paragraph 62)

9. We also recommend that the STFC carry out detailed research into the post-doctoral geographic and work destinations of the researchers that it funds. We would expect the STFC to report on this in its 2012/13 annual report. (Paragraph 63)

Capital grants to universities

10. We are concerned that the reduction in STFC capital grants available to universities over the next four years will mean that vital work in the field of instrumentation R&D, as well as the essential support and follow-up work that requires investment in computing capacity and other supportive equipment, will be neglected. We conclude that the consequence will be a loss in the UK's prominence in these areas. (Paragraph 69)

Accelerator Research and Development

11. Important decisions will shortly have to be made about the allocation of relatively scarce resources for accelerator R&D over the next four years. These decisions will determine whether the UK has a significant part to play in this field for decades to come. Given the widespread applications and benefits of this area of science, the

STFC must ensure it makes these decisions on the basis of a long-term, scientifically-informed, strategic vision that ensures the UK stays at the forefront of activities in developing new technologies. (Paragraph 76)

STFC 'in-house' focus

12. We welcome the STFC's clarification that proposals in its delivery plan will not impact on technical R&D work carried out in universities. However, the STFC must ensure that what it says is a restatement of the current working relationship between university groups and the STFC's own laboratories does not result in the construction capabilities and the expertise within UK universities being underused in favour of focusing future construction activities at the STFC's own laboratories. (Paragraph 80)

Existing infrastructure

13. While in the short-term the impact of capital reductions on existing facilities may be manageable, the STFC must ensure that, if opportunities for increased capital investment arise during the next four years and beyond, it prioritises maintaining the cutting-edge capabilities of the UK's existing scientific infrastructure. To enable the STFC to plan properly for the next four years, we urge the Government to make clear its allocations to Research Councils for capital spending beyond 2011/12 as soon as possible. (Paragraph 83)

Concentration of funding

14. We recognise the significance of astronomy and particle physics to a wide range of important scientific developments. We conclude it is therefore important that the STFC ensures current and future investment decisions protect the breadth of this work and ensure the UK is at the forefront of future developments in astronomy and particle physics. (Paragraph 86)

The UK's international reputation

15. We are concerned that past and future decisions to withdraw the UK from internationally collaborative projects and the subsequent impact on the UK's international reputation may affect the potential future gains from such collaboration that the STFC, and other research councils, expect to achieve. Indeed, there appears to us to be a danger that the UK's track-record may hinder its ability to join, and be seen as a leader in, future collaborations. The assessment by Sir Adrian Smith, Director General for Knowledge and Innovation at BIS, is that the UK is not seen as an unreliable international partner. We conclude, however, that this does not fit with the assessment of the Institute of Physics and Professor Stephen Hawking who, in our view, are in a better position to make a judgement on this important matter. (Paragraph 89)

STFC engagement with researchers

16. We note the President of the Institute of Physics' comments on recent improvement made by the STFC in its engagement with researchers. Some lessons from earlier failures in communication and engagement have been learned but there is still a large amount of room for improvement. (Paragraph 92)

17. We conclude that one simple step towards winning back the trust of researchers would be to ensure that researchers and academia are sufficiently involved in the high-level decision making in the STFC on a consistent basis. We recommend that the STFC make a permanent commitment to ensure that at least 50% of STFC Council members are practicing academics and include at least one individual from each of the core scientific fields for which the STFC is responsible—astronomy, particle physics and nuclear physics. (Paragraph 95)

Future communication and the next STFC Chief Executive

18. The next STFC Chief Executive must make it clear from the outset his or her commitment to work with researchers and academics, and act as an advocate for all of the science disciplines covered by the STFC. We will continue to scrutinise the actions of the STFC throughout this Parliament, and will invite the next STFC Chief Executive to appear before us at the earliest available opportunity. (Paragraph 99)

Outreach

19. We conclude that outreach is essential. We believe there is scope for a more dedicated and defined outreach role for some researchers and institutions funded by the STFC. We recommend that the STFC investigate opportunities within specific grant applications of university groups and institutions to allocate defined, ring-fenced funding for the employment of active researchers to carry out dedicated outreach and public engagement activities as an integral part of their role. (Paragraph 105)

20. We believe the STFC should exploit its network of strategic partners in the public sector, universities, learned societies and industry and act as a conduit in developing, coordinating and promoting a formal programme of outreach between these partner organisations and schools. The STFC's delivery plan specifically outlines plans to strengthen its strategic partnerships and we recommend that outreach be seen as a key element of work in this area. (Paragraph 110)

21. At a time when the public profile of astronomy and particle physics is high, we are concerned to learn that the funding made available for public engagement award schemes within the STFC's Science in Society programme has already been squeezed. The STFC must look to protect and increase this area of funding wherever possible. (Paragraph 113)

22. Especially in these financially constrained times, the Department for Education and RCUK should seek to foster relationships between research councils, local education authorities and schools in order to enable research council employees, and research

council funded-researchers, to carry out outreach activities on a more systematic and coordinated basis in primary and secondary education. (Paragraph 116)

The National Schools Observatory

23. It is unacceptable that senior civil servants have passed the buck on the future of the NSO. This 'silo mentality' which pervades government and is a clear barrier to any notion that Whitehall is becoming more 'joined-up' means relatively cost-effective educational research projects, such as the NSO, which are so important to inspiring the next generation of scientists, risk being lost. Clear mechanisms must be put in place to stop issues like this falling between ministerial, departmental, and research council responsibility. (Paragraph 121)

Annex 1: List of acronyms and abbreviations

ALICE	Accelerators and Lasers In Combined Experiments
ALMA	Atacama Large Millimetre/submillimetre Array
BIS	Department for Business, Innovation and Skills
CCAT	Cornell Caltech Atacama Telescope
CCLRC	Central Laboratory of the Research Councils
E-ELT	European Extremely Large Telescope
EMMA	Electron Machine with Many Applications
ESA	European Space Agency
ESO	European Southern Observatory
FUAP	Far Universe Advisory Panel
GBFR	Ground Based Facilities Review
ILC	International Linear Collider
ING	Isaac Newton Group
INT	Isaac Newton Telescope
JCMT	James Clerk Maxwell Telescope
JAC	Joint Astronomy Centre
JIVE	Joint Institute for Very Long Baseline Interferometry in Europe
LHC	Large Hadron Collider
LJMU	Liverpool John Moores University
LOFAR	LOw Frequency ARray
LSST	Large Synoptic Survey Telescope
LT	Liverpool Telescope
MROI	Magdalena Ridge Observatory Interferometer
NUAP	Near Universe Advisory Panel
PPARC	Particle Physics and Astronomy Research Council
RCUK	Research Councils UK

SKA	Square Kilometre Array
STFC	Science and Technology Facilities Council
UKIRT	UK Infrared Telescope
VISTA	Visible and Infrared Survey Telescope for Astronomy
VLT	Very Large Telescopes
WFMOS	Wide-Field Multi-Object Spectrograph
WHT	William Herschel Telescope

Annex 2: 2009 STFC prioritisation exercise

The 2009 Ground-Based Facility Review panel's final priority list for UK-funded facilities is summarised below:[200]

	High cost(>£5m/yr)	Medium cost(£1-4m/yr)	Lower cost(<£1m/yr)
Very high priority	ESO subscription (VLT, ALMA, VISTA etc) SKA, E-ELT	ELT instruments	
High priority		N.Hemisphere 8m access WHT to 2017 JCMT to 2014 WFMOS on Subaru e-Merlin to 2014 UKIRT(if UPF) to 2014 LSST (UK Role) CCAT	LOFAR running costs SuperWASP to 2012 Wide field units Alma Regional Cent. MROI
Medium high priority	25% share in Gemini partnership	MOS on WHT	MROI beam-combnr
Good science but lower priority			INT JIVE LT Gemini support

The key decisions made by the STFC following its 2009 prioritisation exercise in relation to astronomy and participle physics projects are summarised below:

projects to be funded:

Astronomy - Advanced LIGO, JCMT (to 2012), Gemini (until end 2012), ING (to 2012), KMOS, VISTA, Dark Energy Survey, E-ELT R&D, SKA R&D, SuperWASP, e-Merlin, Zeplin III; Total cost of £87m over 5 years

Particle Physics - ATLAS, CMS, GridPP, nEDM, Cockroft Institute, IPPP, LHCb, MICE, SuperNEMO, T2K, John Adams Institute; Total cost of £155m over 5 years

Projects subject to discussions leading to managed withdrawal:

Astronomy - Auger, Inverse Square Law, ROSA, ALMA regional centre, JIVE, Liverpool Telescope, UKIRT. Additional reduction imposed on ongoing projects of £16m. Total savings of £29m over 5 years

[200] The Chair and Vice-Chair (Professor Michael Rowan-Robinson and Prof Robert Kennicutt) the Ground Based Facilities Review have both submitted evidence to the inquiry (Ev 43 and Ev w20). The priority list is summarised from Ev w20.

Particle Physics - Boulby, CDF, D0, eEDM, Low Mass, MINOS, Particle Calorimeter, Spider, UK Neutrino Factory. Additional reduction imposed on ongoing projects of £25m. Total Savings of £32m over 5 years

Annex 3: Selected astronomical facilities with UK involvement[201]

ESO optical/infrared facilities

The European Southern Observatory (ESO) operates optical/infrared telescopes at the Paranal and La Silla observatories in Chile, on behalf of its 15 member countries. The UK joined the partnership in 2002. The cost of the UK's ESO subscription in 2010/11 was £29.2 million (this includes around £10 million of residual contribution to entry costs which are being paid until 2011/12).

The current flagship ESO facility is the Very Large Telescope at the Paranal Observatory in northern Chile, comprising four 8.2 metre Unit Telescopes. ESO are now in the advanced design stages of the 40 metre European Extremely Large Telescope, which will be the largest optical/infrared telescope in the world.

Gemini

The Gemini Observatory consists of two 8.1 metre telescopes, the Gemini South telescope on Cerro Pachon in Chile, and the Gemini North telescope on Mauna Kea, Hawaii. The Gemini telescopes were built and are operated by a consortium consisting of the United States, United Kingdom, Canada, Chile, Brazil, Argentina, and Australia. The UK will be withdrawing from the Gemini partnership in 2012. Current costs to the UK of involvement in Gemini stand at around £5-6 million per annum.[202]

Isaac Newton Group

The Isaac Newton Group of telescopes is comprised of 3 telescopes: the 4.2 metre William Herschel Telescope (WHT), the 2.5 metre Isaac Newton Telescope (INT) and 1.0 metre Jacobus Kapteyn Telescope (JKT) based on the Canary Island of La Palma. The telescopes are jointly owned and operated by the UK, Netherlands, and Spain. The UK share of telescope time on ING telescopes has been declining in recent years in line with the reduction in the UK contribution, and the UK no longer uses the JKT. Current operational costs for the ING site are around £3 million, £1 million of which is paid by the STFC.[203] The STFC announced in 2009 that STFC funding would end in 2012.

The Joint Astronomy Centre

The Joint Astronomy Centre (JAC) in Hawaii is an establishment of the STFC and operates the James Clerk Maxwell Telescope (JCMT) and the UK Infrared Telescope (UKIRT). The

[201] Some details in this annex are extracted from: STFC, *Ground-Based Facilities Review Final Report*, 2009, Appendix 1.

[202] Q 105

[203] Ev 41, para 23 [Royal Astronomical Society]

STFC provides funds to the JAC for the operation and management of the UKIRT and for the UK share of the JCMT amounting to £3 million per annum.[204]

UK Infrared Telescope

The UK Infrared Telescope (UKIRT) is a 3.8 metre telescope by the Joint Astronomy Centre. 15% of time on UKIRT is made available to the University of Hawaii in return for the lease of the Mauna Kea site. The STFC announced a "managed withdrawal" of funding for the UKIRT in 2009, however the STFC submission to this inquiry indicated Support for the UKIRT had been extended to 2013.[205]

James Clerk Maxwell Telescope

The James Clerk Maxwell Telescope (JCMT) is the world's largest single-dish submillimetre telescope. It is a partnership between the UK as owners (55%), Canada (25%) and the Netherlands (20%). The University of Hawaii has access to 10% of nights as a site tax. The STFC announced in 2009 its funding would continue until 2012 (when the current international partnership agreement expires), however the STFC submission to this inquiry confirmed a limited extension to support for the JCMT.[206]

Liverpool Telescope

The Liverpool telescope is a fully robotic instrument owed by the Astrophysics Research Institute of Liverpool John Mores University (LJMU). It was constructed on La Palma using funds made available from the European Union and LJMU. The STFC currently provides operational costs for the telescope in return for 40% of the available time. Current operational costs of the telescope are £650,000 per year, of which the STFC contributes £500,000.[207] The STFC announced a "managed withdrawal" of funding for the Liverpool telescope in 2009.

Square Kilometre Array

The Square Kilometre Array is a radio telescope which will consist of three separate types of receptor (a sparse low-frequency aperture array, a dense mid-frequency aperture arrays, and high-frequency dishes) sharing the same infrastructure. It is planned for construction between 2016 and 2023. An international consortium representing more than 15 countries plan to build the SKA and choice will be made around 2011/12 between proposed sites in South Africa and Australia. The UK currently holds a leading role in the European programme of R&D development towards the SKA. The funding proposal for the SKA within the UK is to continue the current R&D programme at around £3 million per year, followed by a ramped uplift to around £10 million per year when the first phase of construction begins in around 2014/15 and continuing at that level to 2019. There would

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[204] Q 106

[205] Ev 52, para 12 [Science and Technology Facilities Council]

[206] As above

[207] Ev 94, para 11 [Liverpool John Moores University]

be an additional £2 million per year running costs from 2017, rising to around £3 million a year in 2019.

Formal Minutes

Wednesday 4 May 2011

Members present:

Andrew Miller, in the Chair

Stephen Metcalfe	Pamela Nash
Stephen Mosley	Graham Stringer

1. *Astronomy and Particle Physics*

The Committee considered this matter.

Draft Report (*Astronomy and Particle Physics*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 124 read and agreed to.

Annexes and Summary agreed to.

Resolved, That the Report be the Fourth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

Written evidence was ordered to be reported to the House for placing in the Library and Parliamentary Archives.

[Adjourned till Wednesday 11 May 2011 at 9.00 am

Witnesses

Wednesday 9 March 2011

Wednesday 16 March 2011

List of printed written evidence

List of additional written evidence

(published in Volume II on the Committee's website www.parliament.uk/science)

List of Reports from the Committee during the current Parliament

The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2010–12

First Special Report	The Legacy Report: Government Response to the Committee's Ninth Report of Session 2009–10	HC 370
First Report	The Reviews into the University of East Anglia's Climatic Research Unit's E-mails	HC 444
Second Report	Technology and Innovation Centres	HC 618
Third Report	Scientific advice and evidence in emergencies	HC 498
Second Special Report	The Reviews into the University of East Anglia's Climatic Research Unit's E-mails: Government Response to the Committee's First Report of Session 2010–12	HC 496

Oral evidence

Taken before the Science and Technology Committee

on Wednesday 9 March 2011

Members present:

Andrew Miller (Chair)

Gavin Barwell	Stephen Mosley
Stephen McPartland	Pamela Nash
Stephen Metcalfe	Graham Stringer
David Morris	Roger Williams

Examination of Witnesses

Witnesses: **Anna Barth**, Camden School for Girls, London, **Jack Bliss**, Allerton Grange School, Leeds, **Jessica Grainger**, Saints Peter and Paul Catholic College, Widnes, **Hilary Lamb**, Stroud High School, Gloucestershire, **James May**, Castell Alun High School, Hope (near Wrexham), and **Charlie Palin**, Neston High School, Cheshire, gave evidence.

Q1 Chair: Welcome everyone. Can I, first of all, thank the six witnesses for coming along this morning? Some of you, I know, had some fairly early travel plans to get here. Those of us in the north-west understand what that means. So welcome to all of you. What we are trying to do this morning is to find out what really switches people on to science. The common theme among all of you is links to physics and astronomy. We are trying to delve into what worked for you and at what age that started to gel. Also, when we meet some of the experienced scientists later on in our other witness sessions, we want to know what they can do to help meet some of the gaps that you and we see that may exist.

Charlie, I am going to start with you because you go to school in my constituency. This is a very rare occasion because, usually, it is the other way round, that constituents get the opportunity to quiz their MPs. Let us have it the other way round. I am going to start with you and then I am going to ask all of you in turn to comment quickly on this question. What originally got you interested in astronomy and physics?

Charlie Palin: The first thing was being interested in science at school. The key thing was having a teacher who engaged well and had a real passion for the subject. Also, I was intrigued by the way things worked. Then I found that that led naturally to physics. But I think it is key that a teacher engages well and shows you what the subject has to offer.

James May: From an early age I always wanted to find out how different things work. Even very early on, I was very interested in the intricacies of things. When I went to high school, I found that there were some teachers who shared that passion and they took courses in physics and astronomy to find out more. Through their enthusiasm, I followed on from that.

Hilary Lamb: I have never not been interested in astronomy and physics because it is the science of everything. I don't understand how you can't be. Since a very early age I've just been rained down with books and TV programmes about astronomy. That has really helped. As well as that, being able to do science rather than just have the textbook approach really got me interested.

Jessica Grainger: I am not from a particular scientific background, so when I started secondary school I had such an opportunity from visiting speakers and so many other interactive workshops. The Science and Technology Facilities Council brought in lunar samples when I was in year 7 and it got me really interested. In year 9, that followed up when I was able to see a laboratory—a working environment.

Jack Bliss: I can only echo the other guys here. It was a desire to understand the way things worked—what made thinks click together. I was also fairly lucky in that I had a teacher who had spent a lot of time in the field. She discovered a few new species of fish and that kind of thing. If you get lucky and you get somebody who is really able to articulate what is good about it, you get it a bit yourself as well.

Anna Barth: I was slightly less lucky in that I had physics teachers who didn't do physics or hadn't done a physics degree. So I never really liked physics until my dad got me a *New Scientist* subscription. Then I just couldn't stop reading it. Then I did an extra GCSE in astronomy, which my school supported, with two other friends, so that helped.

Chair: That answer might please some of the journalists listening in. I will hand over to David Morris.

Q2 David Morris: Most of what I was going to ask in the first part of the question has been answered with what you have said, but have you visited or used any scientific facilities which have furthered your motivation to study astronomy or physics? How important have your teachers and experiences been in pushing you into studying science? I will start with Anna and move all the way along.

Anna Barth: I visited CERN on my first school trip and I found it really inspiring to see the different scientists from around the world collaborating. That was really important. Also, over the summer I was lucky enough to do work experience at UCL and Harvard. In the A-Level course I didn't really get a picture of what a scientist actually does, but from those work experiences that was made clearer, I found

it really inspiring and it made me want to continue my studies.

Jack Bliss: Have you ever been to Magna in Sheffield?

David Morris: I haven't, no.

Jack Bliss: It's great. I can really recommend it. If you've got kids, take them there. It is primary school level science but completely reinvented. It's fantastic. I would say it was probably one of the things that got me interested. I would love to go to CERN but Magna is the next best thing.

Jessica Grainger: My teacher has been involved with the NSO since 1998[1] so, for my work experience, she was able to get me a placement with the NSO at the Astrophysics Research Institute. It was brilliant to see the working environment and how it is a viable career because I had never really experienced it from where I was.

Hilary Lamb: In years 11 and 12, I used the Faulkes Telescope in Hawaii over the internet, which any students in any school can use. In year 11, I discovered some Be stars and made some Hertzsprung-Russell diagrams, and in year 12 I joined in with the search for NEOs. It was really brilliant to be able to take the project in my own direction rather than just follow the instructions in a textbook. That was really great.

James May: I can definitely echo what the other witnesses have said here. In years 10 and 11, I was doing the GCSE physics course, which was a very good course, but the GCSE astronomy course allows you to push yourself that little bit more. Again, by using the Faulkes Telescope and also the NSO, we have used different aspects from them that allow us to expand our knowledge but not in a way that keeps you narrow-minded. It opens your mind and it allows you to push yourself much further than you could have thought. It is very, very good for that.

Charlie Palin: Later on this year, partly funded by the Institute of Physics, we are going to CERN for a tour, which I am really looking forward to because I am interested in that specific area of physics. You can do the course in the classroom as much as you want, but what really inspires and catches young people's eyes into physics is getting hands on with the subject and actually going and seeing what it can lead to, not just learning about it.

Q3 Stephen Metcalfe: Good morning, everyone. How important do you believe the media is in promoting science, whether it is on television or through the papers, in promoting astronomy and physics? Can you each name who is your most inspirational figure perhaps from television or other media?

Anna Barth: I am probably not the best person to ask because I don't watch science programmes on TV. I find reading about it in publications and in the *New Scientist* more interesting, but for a role model, it is probably the woman I worked with at Harvard, because she is a woman in science. She was just great. She was so enthusiastic about everything and just really great.

Stephen Metcalfe: That's interesting. Jack?

[1] Please see APP 42 at Ev 105

Jack Bliss: I don't watch much television either. I have been very disappointed with the few "science-y" television programmes I have watched. They are very dumbed down and they repeat a lot of shots of balloons exploding and stuff. It's all analogy and there's no actual educational value beyond concepts. But I do read *New Scientist* a lot and I try and read publications of things that I am interested in as much as I can.

Q4 Stephen Metcalfe: So you don't think the programmes inspire people to take the same level of interest that you have?

Jack Bliss: No. It is bite-sized little chunks that you can have and then forget about. It is all shot and written to make the person watching feel cleverer than the show is, if you get me. As for a scientist that you can see as a role model, probably da Vinci would have to be one of the best ones because he was not just a scientist.

Q5 Chair: He is not producing television programmes, is he?

Jack Bliss: No, he's not. He's not really around any more.

Q6 Chair: What about current ones?

Jack Bliss: Current ones, okay. Probably none of them. Brian Cox would be the closest because he was in a rock band, but not really.

Q7 Stephen Metcalfe: Jessica?

Jessica Grainger: I think the media is quite important in terms of educating the older generation, who, in turn, enthuse the same enthusiasm within the children. Personally, from the media, I saw Jocelyn Bell Burnell in a programme last year, I think it was, on the BBC. I have respect for her being so successful as a female in physics at a time when it is so difficult to be so.

Hilary Lamb: I think the media is really, really important when it comes to inspiring young people. I am a fan of *Horizon*, which is one of my favourites. It is important to be able to show physics at work rather than just in a classroom. There is a problem because a lot of people, who, perhaps, might not be educated in physics, can look at sensationalist or pseudo-scientific programmes—"The LHC is going to eat the world", that kind of thing—and they will take it seriously, which is dangerous and you have got to try to separate that.

My personal inspiration is Carl Sagan. He is not around any more. I think he was brilliant not just because of his work in astronomy but also because he broke the stereotype that science was inaccessible and not poetic. I have to admit, quite embarrassingly, that perhaps the scientist on TV who has inspired most people I know is *Dr Who*, because it is one of the only positive interpretations of a scientist you get on TV.

Stephen Metcalfe: Interesting. James?

James May: I am of the belief as well that the media is hugely important. It is all around us at the moment, both in the form of television and newspapers. One way or another, it surrounds us. It is also a lot of what young scientists look for. If they look for information,

they tend to use the internet, again surrounded by media.

Although the television programmes give you an insight into the different aspects of astronomy and physics, it takes the more specialised publications like the *New Scientist* to push you that little bit further. That is what some of the TV programmes are lacking. They could do with being able to show us a little bit more and to teach us slightly more as well, rather than just giving us an insight.

Stephen Metcalfe: Thank you. Charlie?

Charlie Palin: I agree with James. TV shows do a very good job at what they are trying to do, which is to appeal to the wider audience and engage with most people. What is essential is for people to read current publications, such as *Physics World* and *Focus* magazines from the BBC, so that they cannot just see it on TV and get a little insight but engage deeply with current affairs as to what is happening. I think that is essential.

Stephen Metcalfe: Thank you.

Gavin Barwell: Good morning. I studied theoretical physics at university, but aside from my membership of this Committee I have not used it since I graduated.

Chair: Shame.

Q8 Gavin Barwell: What are all your plans in terms of future study and what do you see yourself doing career-wise in the future? To give someone else a chance of going first, Jessica, do you want to say something?

Jessica Grainger: I was really focused on a career in physics, but I wanted something that had a more humanitarian aspect to it. So I decided to do medicine and I am really interested in the applications of physics. I am looking to do medicine and then, hopefully, to specialise in radiology and be able to work with physics in that way.

Hilary Lamb: I am starting my MScience in physics this autumn. The idea of a career in research does appeal to me, but there is an issue in that if I want to have a career in research I will have to stay in a university rather than work for a company. There are some physics students who might end up moving to the Netherlands, where there is the ESA, to Switzerland, where there is CERN, or America with NASA, because there is a certain lack of jobs that use these skills in theoretical physics and astronomy.

James May: I have always had an interest in aviation. I have always wanted to follow that up. Again, it is very closely related to physics and to astrophysics. So I would probably be more interested in finding a degree subject that gives general access but you can also specialise in aviation engineering. I think it is very closely linked to most areas of physics. After that, I would probably go into astrophysics purely because it is more mathematically based and I find I do enjoy it more.

Charlie Palin: I have known for a very long time that physics was the route I wanted to take and that is what I wanted to do when I went to university. I also think that, after that, I would love to go into research. That is why it is essential that we continue pushing and funding programmes like CERN so that young people from the country who have just graduated from university and want to follow a research path have somewhere they can go and look to if that is what they want to do.

Anna Barth: I am planning on doing physics and natural sciences at university, and a career in research would be really exciting, especially after the work experience that I did, but I am not sure. A month ago I thought, maybe, I was going to be a cello maker because I play the cello. So I am not sure about the career, and my desire to do it at university isn't motivated by the career.

Jack Bliss: I was considering doing maths for a long time at university, but it's not practical. You don't do a lot. You just sit round thinking, so I'm applying to do electronic engineering, specifically robotics, which is probably what I am going to end up doing, hopefully. Either somebody in the military or a toy company will give me a job, because those are only the two real things you can do with it.

Q9 Pamela Nash: First of all, may I apologise for being late? This is, probably, the session that I have been most looking forward to since I became a member of this Committee. I was really disappointed that I could not come earlier this morning. From what I have heard so far, I am really impressed by the level of thought that you have put into your future careers. I have to say that when I went to university, which was only a few years ago, I just did what I fancied out of the prospectus and hoped it would lead me somewhere I would like to go to, which has happened. So I think that both methods of choosing your course work.

Do any of you feel that there are any barriers you perceive at the moment to continuing your studies, specifically the girls, and that being female may provide a barrier to your continuing towards your chosen career path? I also ask this question of the boys if you have any insight. I don't know who has not been first yet.

Anna Barth: For females, at the moment it seems pretty good because we are so rare. Because of positive discrimination we have it easier, maybe. There is definitely a lack of female role models. I question why that is. It seems that, since it is such a male-dominated field, it could be a bit intimidating, so I am not sure.

Jack Bliss: I don't think I have any barriers, really; no, nothing. I don't see any barriers I could face in getting into physics at all.

Jessica Grainger: I have always had female physics teachers so I never even thought of it as being a barrier, to be honest. I think it is lucky that we are studying science at a time which is so accepting of women.

Hilary Lamb: I haven't come across any barriers myself, but I think a lot of people give up physics after GCSE because they think it is not going to lead to anything. I have to admit that the GCSE course is quite dry. For girls, unfortunately, it is seen as unglamorous. I think that does need to change. That might be what is holding a lot of people back, even though it is self-imposed, I am sorry to say.

James May: There are not a huge amount of barriers. If you have the determination to do something, it is

quite easy that you can do it. If you are willing to put up with the challenges you may face along the way, it's still perfectly capable of doing. Unfortunately, as some people at the moment may find, one of the main problems is the cost. Further education does come with its own fees. I am not hugely versed in them at the moment, but I know that big changes are coming with university tuition fees. I think that may put some people off, which would be a huge shame; it really would.

Charlie Palin: I would like to echo what Hilary and James said about the fees. I also think it is crucial that people taking physics and people who want to do physics don't just see the short term in going to university. It is really good if they can see where they are heading and where they want to be placed after university. So they don't just have a short-term plan; they know that it will lead to something. I think that is important.

Q10 Pamela Nash: Can I just follow up on that? Do you have any ideas, then, how we can show young people what careers they could have and not just the courses?

Charlie Palin: Work placements, pushing summer schools and stuff like that. We need to get companies to contact students, talk to them and show them what they have on offer after they have done their university course.

Jack Bliss: It is partly to do with the syllabus. When you sit in a science lesson and you do some of the experiments, they seem completely irrelevant and there is no connection to any real world application. You need to try and have a syllabus that has a more practical focus. I do not mean actual experiments, sitting in a lab, but things that are relevant to the way we work as human beings.

For example, I've got no idea how a computer works. I use one every day and I am fairly familiar with a few programming languages, but I have no idea of where things are pushing things. We even do electronics. We are doing electronics in science at the moment, and I still don't know. It is all theory. It is all ground work. There is no solid application.

Hilary Lamb: I know you have to learn from the textbooks the names of the planets over and over again in your earlier years, but it's not useful just knowing that. It is so much more motivating to be actually doing some research yourself. If young people saw that they could do things that were useful that pushed the frontiers of research rather than making notes on Moments from a book, I think that would be a lot better for young people.

Anna Barth: I agree with that. I think that course work is a good opportunity to do those kinds of things. In my experience, the course work is just memorising lists of things that you have to say and then carrying out an experiment that you have already done five times. So there is no element of discovery in any of the physics course.

Jack Bliss: You watch a ruler twang backwards and forwards.

Q11 Chair: Jessica mentioned the STFC bringing in lunar samples to your school. I have to say I can never forget the thrill I had the first time that I handled a lunar sample. It was from the very first Moon landing, which was phenomenal. It is just a buzz, isn't it? It really makes you think.

Jessica Grainger: Yes.

Q12 Chair: Have any of you others had experiences like that driven by the STFC or any other organisation?

Jessica Grainger: I had a letter from the STFC. I won a science prize in year 9 and it was funded by the STFC. It was based at the Daresbury Laboratory, which they were funded through. It was really good for looking at careers in science. Afterwards, they realised that we were people who were interested in science and they took us on a tour. We were able to ask questions to see what they did.

Chair: Anybody else?

Jack Bliss: The only experience that I have had of anything similar to what you had was the first time I realised the implication of what was happening. I was in a car and I saw the glare bouncing off the back of a car in front of me. It was the first time I really understood what that glare was, like photons travelling all the way from the Sun, a straight shot, eight minutes' old light, bouncing off the car and into my eye. It is humbling to think that it had come all that way and it was just not going to do anything useful from then on.

Q13 Chair: That was something you saw but nobody else introduced it to you.

Jack Bliss: Yes. Nobody has ever really done anything like that, no.

Hilary Lamb: I think that everybody needs to watch *Cosmos*. That really does put a different spin on things.

Q14 Stephen Metcalfe: How do you think your peers view your interest in science—physics and astronomy? Have you ever experienced any pressure not to do that? Hilary talked about it not being very glamorous. Are there more negative connotations to your experiences?

Hilary Lamb: Yes. People think I'm weird, to put it bluntly. There are not many people at all doing physics. It is the least popular subject in my 6th form. I don't know why they think I'm weird. It is probably because they think it's just spending a lifetime doing differentiation. Then, again, going back to the media, when they see programmes by Brian Cox, they can see why I am interested in it. There is an overwhelming attitude, which is that physics is boring. I don't think that is fair.

James May: It is quite closely linked as well to the teachers you have for that particular subject. I find that I can self-motivate myself into research at certain times, whereas some of my peers can't do that. I think it is the teachers' lack of motivation and they are not being able to push, rather than just sitting with a textbook and telling us things out of the textbook. They don't push us, whereas some people can push themselves. The people who can't do that tend to struggle more.

Charlie Palin: There is definitely a stereotype apparent about people taking physics. It is all about being locked up in a really hot stuffy classroom with books and working things out. I think this can be addressed by showing what it can lead to in work and showing that it is not just books in a classroom. It is a matter of addressing the stereotype.

Q15 Stephen Metcalfe: Does anyone else want to comment?

Anna Barth: It is actually really positive at my school, and I think, definitely because of the two really good physics teachers I had, not very many people dropped it from AS. I know that there is a stereotype out there, but I have not really experienced it personally.

Jack Bliss: I have never ever been pressured into not doing physics. People think it is lame but nobody has ever said to me, "You shouldn't do physics." In fact, you have to find the right moments to bring it up, but nobody ever tells you that it is stupid. It is one of those stereotypes that I am aware of, that doing science and being interested in science is not cool, but I have never had any proof or evidence of it.

Jessica Grainger: People seem just to accept it. I have done science and maths since I started at the school. My friends have just accepted that that is what I do. If anything, people are interested as to why I am interested in it, rather than trying to stop me from doing it in the first place.

Hilary Lamb: There are times, sometimes, when I am sitting in a physics lesson watching water boil and a thermometer, and I think, "What am I doing?" When I tell a friend, "I found a Be star", they say, "That's interesting. What's that?" I think a lot of it is about the syllabus. They have had bad experiences with the syllabus at GCSE standard.

Charlie Palin: I think that is a key for the teacher to also ignite the passion and show that there is no stereotype lower down the school, at the GCSE and before that. There is definitely a stereotype. They can get rid of that.

Stephen Metcalfe: Thank you.

Q16 Roger Williams: Thank you very much. Without building your egos up too much, I guess that everyone around this table would think that enthusiastic young scientists like you are the most precious asset that we have, and much more precious than facilities. Some of us do scientist pairing schemes where we have young scientists who have just done their doctorate, for instance. Although they are still enthusiastic, they are perhaps not quite so enthusiastic as you are. Do you know anything about the career structure in science? If you do, what could we do as a Committee to ensure that we lay out a path for you that would encourage you to keep up your enthusiasm and keep you working in science?

Jack Bliss: Keep being scientists, really. Science is self-propagating because it begets itself. The more you know, the more you can learn. The only thing that is going to stop more scientists from emerging is for science itself to stop. Beyond that, nothing.

Q17 Roger Williams: Have you talked to people who are having a career in science or are a bit further on?

James May: I have not looked into it too much, but that is primarily because we have not been told very much about it. Maybe at a younger age, maybe as far as GCSE level and definitely A Level, to be able to be offered a position, like a work experience placement, if you like, and to be able to push a little bit more to learn what you want to learn by shadowing somebody, for instance, could give you the extra help you need to follow the course and, again, further on, maybe at degree level, to shadow somebody slightly higher up, just to keep your path where you want to go, really.

Charlie Palin: I definitely think the closest I ever came to understanding what careers there were was a work experience in year 10. It is definitely key that there are more schemes like that that happen so that there are more students going out into the field and seeing what it can lead to and not just the syllabus itself.

Hilary Lamb: I did my work shadowing with British Energy. I found it was really positive. There were lots of graduates who were working with British Energy and they were hoping to get jobs with them afterwards. Something I would say is that I think it is pretty easy to get a job in science because you will always need scientists, but something that is a bit harder, and this is an inquiry into astronomy and particle physics, is getting a career out of something a bit more theoretical. I think that is harder in Britain. You might have to go over to Europe to do that.

Jessica Grainger: Any experience that I have of the structure of scientific careers has come from speakers we have had in the school or from work experience, again. I think those were the most important things for me, really.

Anna Barth: My work experience, again, was very important. One thing that made me a little bit nervous, and I don't know what could be done about it, is that, at Harvard, UCL and even with the science teachers I have now, a lot of their time is spent trying to work out where they are going to get funding from for different projects and getting grants and less time actually doing science. That doesn't seem too appealing.

Q18 Stephen McPartland: I have a couple of quick questions. Are any of you aware that the UK Space Agency was created last year? Secondly, have any of you had the opportunity to go into a company and see them use science at the cutting edge to push forward the barriers? For example, in my constituency we have a couple of thousand people who produce 25% of the world's telecommunication satellites and a huge variety of physicists, and people are involved in a whole variety of different earth observation techniques and everything else. Have you had an opportunity to go into companies like that, to meet people, to see that there is a career structure and that there is a real opportunity to push forward as individuals in your own field? No.

Jack Bliss: Is the UK Space Agency like NASA?

Stephen McPartland: It is a very small version.

Jack Bliss: A very small NASA. No, I did not know that.

Q19 Stephen McPartland: Does anybody else want to say anything?

Jessica Grainger: I went to the NSO—the National Space Observatory—and the Astrophysics Research Institute and I saw the PhD students working alongside science. I was able to see the research they were doing and take part in it.

Hilary Lamb: I was aware that there was a British Space Centre, but all I know about them is that they rejected a lot of people from my school for work experience.

James May: I had not heard about it, but I think it is exactly what we are looking for, to encourage younger scientists to go into such a field. Something like that can stimulate you and show what can be done with space in the UK and astrophysics. Something like that is what we need.

Charlie Palin: I have actually heard of that. It is vital that organisations such as those that you have mentioned engage with students of today and show them that there are paths to take and things to go on to.

Hilary Lamb: It is very small, though. It has only got about 700 employees, as far as I know.

Q20 Stephen McPartland: The UK Space Agency has, yes. The Chair was speaking earlier about the gratification he felt when he held a piece of lunar rock. If you were students in my constituency, the company Astrium would allow you to come in and look at the Mars Yard, see the Mars Rover, look at the Beagle satellite and see the inside of it. It would allow you to look at how a satellite is designed and manufactured. Is that something a student should be interested in doing and actually seeing the practical application of science going forward?

Jack Bliss: Yes. A lot of people aren't aware that there are careers in—I don't know what the word would be—space beyond being an astronaut. People assume that that is all there is to it, really. People need to know that there is so much more with people working behind it.

Charlie Palin: That is exactly what we need. We need trips like that to see the real application. It just takes one trip to change and inspire someone who is undecided about taking a different science, physics or biology, just to go on that trip. If that happens to only one student, then the trip is worthwhile. That is what is needed.

James May: The syllabus does a very good job of putting the foundation down for this sort of thing, but to be able to be pushed more and to want to spend the rest of your life in a certain field you do need that ignition of the fire at the very beginning, through either a field trip or something very similar, because that is what pushes you that little bit more and then you start thinking outside the classroom of the different applications of what you have learnt in class. I think that is what pushes you further.

Anna Barth: Yes. If there could be some link between the course that you are studying and things you get to see with their practical applications, like going to a company or seeing someone doing research so you can make that link and, even though what you are studying at the moment might not be so interesting, you can see how it would be if you just understood more about it.

Jessica Grainger: I think it needs to be done from an earlier age as well. From my own experience, a lot of my friends, by the time they had reached high school, had already decided that science wasn't for them. So, with any speakers that we did have in, they just switched off to it. They weren't bothered as to what they had to say, anyway.

Q21 Chair: That takes me on to a question that I want particularly to put. I have no doubt, Jessica, you went to the Catalyst Science Discovery Centre in Widnes.

Jessica Grainger: Yes.

Q22 Chair: It is great fun, where you see real live chemistry. The great advantage in my day was that we were allowed to do it ourselves and cause explosions and things, which is perhaps not a good advert, but it was good fun. When you were all at primary school, what was the missing link there? Several of you have referred to inspiring teachers. Did you have that at primary school? Do you see that as a gap in the system—that there are not sufficient teachers with physics experience in the primary sector?

Jack Bliss: I don't think it is a lack of experience as such. A primary school teacher has to be able to teach everything. They have to be able to teach history, English, maths, science and all of it to the same standard. A person who is good at everything will never have a real passion for any of those individual subjects, or, if they do, it is less likely to come through. If you want to get young primary school kids really interested in science or any subject, you have to have somebody who is interested in it and who will pass it on to them. It is not that the teachers are not good enough, that they don't know enough or that they are not interested enough. It is that they don't spend all of their time doing it. They are too broad.

Charlie Palin: I think the key turning point is at the beginning of secondary school where you have just joined secondary school, you are settling down and it is then that you are getting a feel of where you want to go to and where you want to head to. It is between the primary school and the GCSE period that you cannot see where you want to go. The process from choosing your GCSEs, choosing your A Levels and choosing your university to a job has to be streamlined, and you need help, definitely, at the last stage, about seeking a placement and a job.

Hilary Lamb: Young people—young children—are naturally, very, very inquisitive, and you can tell that from the way they are always asking questions, such as "Why is the sky blue?", "Why is the earth round?", etcetera. I don't think they necessarily make that link between answering those questions and the science they do in primary school. I remember in primary school I had one science lesson a week, and between the three sciences that is one physics lesson every three weeks. I was very curious, but I definitely didn't make the link between the science in manufacturing

and astronomy and the science we did in school. It was only really a dribble of science.

Anna Barth: It was definitely less important than English and maths in primary school. We only had one lesson every week and it wasn't taught by someone who really liked science. We never really did experiments. So I wasn't interested in it at all. Even in secondary school, I did not enjoy it, I think, because my teacher did not do physics. I think the main thing is having a teacher, especially at secondary school, who does physics and can inspire the kids.

Jessica Grainger: I had a slightly different experience. Similarly, my teacher was just a general teacher who taught us for everything, but at the time we were one of the last year groups to do the SATS. The SATS was a big focus. It was getting students up to standard in English, maths and science, so we did have frequent science lessons, but they supplemented it really well. At the school I went to, SetPoint came in a lot and they just did experiments. It was more fun-based rather than learning but you knew that you were doing science at the same time.

Q23 Chair: Have any of you something that is burning you up that you want to tell us about this subject before we finish?

Charlie Palin: It is critical at high school level, specifically at A Level, that the physics teachers we have actually have a degree in physics and are passionate about physics, and are not, say, biology teachers teaching physics. I think that is crucial.

James May: At the moment, the young scientists are the physics and other science teachers of the future. So engaging the young scientists at the moment and making them interested in science, making them find their own passion, is what is going to secure the future, and making sure that future generations can find their passion for physics as well. At the same time as what we need, it is also what the future needs as well.

Hilary Lamb: It is enormously important to get rid of what I call the textbook approach to physics because, if students just learn physics out of a textbook all their lives, that is all they think it is. It is more important to get them doing science and get them actively involved in the things they find interesting and inspiring.

Jack Bliss: It is this whole idea that physics and science is very set. "You have to know this", "These are the facts", but it is not. Throughout history, scientists have constantly been persecuted for coming up with new ideas that they found out were right. Galileo was imprisoned and had to surrender himself on his death bed. If you teach kids like that, they are naturally going to resent it. Young people hate authority. They hate being told what's right and what's good for them. I know I am giving you problems rather than solutions and I have no idea how to fix it, but that is the problem.

Chair: That's our job.

Charlie Palin: Less rote learning and a more practical base to catch their eye by experiments.

Anna Barth: As we have said, we need more ways to do work experience. I know that the teacher who got me my work experience tried to get lots of kids work experience but could not find that many places. If there was more of a system that allowed kids to do that themselves, that would be good.

Jack Bliss: A friend of mine was really interested in chemistry and she wanted to go into a chemistry career, but she could not find anywhere to do a work placement. She had no idea of what to do or where to go.

Chair: Thank you all very much. That has been a really helpful session. Can I also thank the teachers who have travelled with you and all of you who have had to get up at some ungodly hour to get here on time?

We are now moving on to our second panel. Just before you go, I don't know but there may be a couple of journalists in the room. If anyone wants to speak to any of the young people here, Becky, our press officer, will try and co-ordinate that outside of the room, but you are, of course, welcome to sit in and listen to the rest of the session as well. Thank you very much indeed for coming.

Examination of Witnesses

Witnesses: **Dr Maggie Aderin-Pocock**, Space Scientist, Astrium Ltd and Science Innovation Ltd, and **Professor Jim Al-Khalili**, Professor of Physics, Professor of Public Engagement in Science, University of Surrey, gave evidence.

Q24 Chair: Can we welcome all three of you as witnesses? I look forward to the answers from the third one.

Dr Aderin-Pocock: She can be quite vocal, by the way.

Q25 Chair: I will start with a very simple question, which follows on from what we have just been discussing with the young students. What inspired you to follow your chosen careers?

Professor Al-Khalili: I would have been about 13, so well into secondary school, when I fell in love with physics. My mother came from an arts and music background. She was very musical so I was very interested in art and music. I was pretty much happy with all of my subjects, but round about the age of 13 or so I did particularly well on a physics test, and I thought, "Oh, I'm quite good at this. I think this is the subject for me." From then on, I never looked back, but I was never one of those kids who had a telescope or dismantled radios, at least not until I was about 13.

Dr Aderin-Pocock: For me, it was much younger but slightly older than my daughter. I used to watch a television programme called *The Clangers* when I was about two or three, and they lived in space. Also, when I was growing up I heard about people like Yuri Gagarin and Neil Armstrong, so I thought that space was the natural thing to do. When I was growing up,

I was held back and I was put into remedial classes, because I suffered from dyslexia, my parents broke up when I was quite young and I went to lots of different schools. The idea of getting into space seemed a long way away. But I had that inspiration of *The Clangers* and the idea of space. Also pictures came along of amazing galaxies and things like that and they totally inspired me, so I was able to overcome the difficulties with the dyslexia and have a dream of space and become a space scientist.

Q26 Chair: During your studies, how important was the funding you received, the people who taught you, and the access you had to up-to-date facilities?
Professor Al-Khalili: Do you mean university studies or back at school?

Q27 Chair: Would you cover both if you feel it is relevant?
Professor Al-Khalili: It was slightly different for me because I spent most of my schooling years in Iraq. I did not come to the UK until I started my A Levels. So I only spent two years of schooling in the UK at a comprehensive in Portsmouth. I wasn't particularly aware of whether the facilities and the laboratory were very good, how they compared with other schools and how they compared with other friends of mine at different schools. I do not think I would be able to judge how I felt at the time. Certainly, university laboratory equipment and funding was very different from the school and that was a new world for me. I never felt as though there were any constraints or anything missing that I would have liked to have seen. This was the early to mid-1980s.
Dr Aderin-Pocock: When I was growing up, I wasn't aware particularly of funding going into our schools or anything like that. By the time I got into university, I went to Imperial College, they were well funded and we had very good equipment and laboratories. They were fairly old but very good. The real distinguishing feature was the teaching. We had unbelievable teaching and we had access to all the professors in the university, and that made all the difference.

Q28 Chair: If you were picking the priorities in the near future, you are, presumably, arguing that investment in teaching and researchers is more important than facilities.
Dr Aderin-Pocock: I don't know about that. That is a little sweeping from what I said. Especially in terms of a subject like physics, the facilities are very important and we learn by doing. I am an experimentalist. The hands-on part, especially for me, was very important. If the facilities go on a back burner, you can suffer. That is one of the problems that schools are facing now. They are not doing so much hands-on experimental work. They are talking about it. They are looking it up in textbooks, but they are not doing the hands-on physical. That makes a whole world of difference. I don't think you can ignore facilities, but at the same time you do need the inspiration of good teaching. They go hand in hand. I don't think you can put a particular emphasis on one and not the other.

Q29 Chair: So you would be reluctant if one budget was cut in preference to the other.
Dr Aderin-Pocock: Yes, I would be very worried.
Professor Al-Khalili: I am a theorist, but I agree entirely with Maggie. Over the years, the time that students spend in laboratories, and certainly in experimental classes, has gone down. Regardless of what area of science you go in, it is vitally important that you have enough time to do the hands-on stuff. We would have done things with ticker tape, batteries, springs and ripple tanks. School curricula have moved on in terms of the science, bringing it up to date, making it more relevant and making it more exciting. To some extent, in relation to laboratory equipment, the infrastructure hasn't moved with it. There is, probably, a lot of virtual simulations on computers, which I guess is necessary, and it is also getting very good, but time spent in laboratories doing, echoing what the students were saying were earlier, is vital.

Q30 Chair: Given your background, Dr Aderin-Pocock, and the difficulties you described in the early stages of your career, are we seeing changes now in the mix of students coming through and the opportunities for a better cross-section of society? Is that happening?
Dr Aderin-Pocock: Not as much as I would like. Science is still seen as a subject for an elite work force. I spend a lot of my time trying to broaden people's horizons. I spend quite a bit of time in inner-city schools, and kids there would never consider a career in science. They think that scientists are white, middle-aged men wearing dickie bows. That is just not them at all. We need to do more inclusion because a barrier still exists. People think, "Oh, science just isn't a career for me", and it is a matter of trying to work out ways of overcoming that barrier and making science much more accessible. I'm sure my daughter would agree.
Professor Al-Khalili: Things have changed somewhat in trying to broaden access to science, but I find very often that the invitations I get from schools to go and give talks invariably come from the independent schools. They are better resourced, they have more time and there is less pressure on their teachers. To some extent, when you visit those schools and you see that some of their laboratories are equipped as well or better than a university laboratory. You are preaching to the converted.
It is the state schools where they have never even seen this sort of thing and you go along with liquid nitrogen and dunk bananas in it. They go away and that has blown their minds. Whether the teachers don't have the time, whether it is the pressure or they don't know how to approach professional scientists and invite them over, I don't know, but that is a far more worthy thing to do than going to some of the bigger and better funded independent schools.

Q31 Roger Williams: What are the future dangers as far as outreach of science is concerned and inspiring the next generation?
Professor Al-Khalili: At the moment, we are at a very good place in terms of outreach. The UK undoubtedly leads the world when it comes to engaging the public

in science. We have moved on from the idea of a public understanding of science, what we call the "deficit model", where the expert stands up, delivers a lecture and the audience are the empty vessels to be filled with their knowledge. Now, there is a much more two-way process in engagement. The UK does better in that than any other country in the world. We have very good media coverage of science now. The science correspondents on the major papers are themselves well-trained scientists. Of course, there is a danger that this situation won't last. Part of what we are talking about today, I guess, is how reduced funding for scientific research will impact on our ability to inspire and to engage. There is that danger on the horizon that we are aware of.

Dr Aderin-Pocock: Science engagement in the UK is at an all time high, as Jim said, but we can't rest on our laurels. I also have a fear that sometimes, through science communication, we are reaching the people who are already interested in science. Sometimes we are trying to find alternatives, in trying to get to the people who are not interested in science and show them how wonderful it is. I have a fear with funding cuts that funding may, in the future, may become very focused on solving problems, be it climate change, ageing and things like that, and that we will lose some of the blue sky wonder of science. What got me into science was looking out "there"; it is the wonder of the universe. If we start reining in and only focusing on current problems, we will lose that long-term potential and we lose that sense of wonder. That is one of my biggest fears at the moment.

Q32 Roger Williams: Do you think there is a role perhaps to embed outreach in grant applications, for instance? As well as doing the work, there should be some obligation to disseminate it to a wider audience?

Dr Aderin-Pocock: I think that is a very good idea, but it is a double-edged sword. I have been to some schools to give a physics talk, and they said, "Yes, we had a physicist in last year", but fewer kids wanted to do physics after they came in than before. Making it compulsory for everybody to go out and do outreach isn't a good idea. Some people have an ability to communicate and some people have an ability to do research. Some people have both and that's the ideal. When people get Government funding, with the taxpayer paying for it, it would be nice if the taxpayer is aware of what is going on and how useful that funding is, but to make it compulsory you need to be careful how that is done because you don't really want to let some people out into a school as the consequences may be grave.

Professor Al-Khalili: What has also happened is that PPARC, the predecessor of STFC, had as part of their grant applications a provision that they had to spend a certain fraction, be it 1% or whatever it was, on outreach and public engagement. In practice, what tended to happen, particularly for large departments, was that the grant money for public engagement was pooled into one pot and then the department had someone who was good at outreach and public engagement, and they were doing it on their behalf. That is certainly a good way of doing it.

Far more scientists should be involved in outreach, but not everyone. The barrier there is that many—particularly young scientists in their early careers as post-docs or young lecturers—feel that there is a pressure to focus only on the next grant application, the next paper to publish and the next conference to go to. So going and talking to school kids is a distraction and a waste of time. That situation, thankfully, is changing dramatically. Since I have been involved in outreach and science communication in the last 10 or 15 years, it has moved from something that was very much frowned upon to something that is perceived within most higher education institutions now as a valuable part of what a practising scientist should do.

Q33 Roger Williams: The next suggestion I was going to make to you is that, with the way funding is going at the moment, there will probably be less opportunity for scientists to do this outreach work and they will be more concentrated on their core work.

Professor Al-Khalili: That is a worry that I certainly have. Although my research is funded by STFC, I hold what is called a media fellowship by EPSRC, so they pay parts of my salary to the university to buy out my time to do outreach. While there are still discussions as to how EPSRC spend their money on outreach, there is this move into embedding it within the research grants. I find that situation very worrying because it can then get swallowed up and fall into holes where it is not used as efficiently and effectively as it probably could be.

Q34 Roger Williams: Professor Steve Jones is doing some work, as I understand it, on science in the media. Have you given any evidence to his work? Have you talked to him about that, or what are your thoughts about the work that he has done?

Professor Al-Khalili: This is what he has been commissioned by the BBC to do about science.

Roger Williams: Yes.

Professor Al-Khalili: I responded to him, talking about my own personal experiences of the production of science programmes on TV, particularly on the BBC. Of course, last year in the BBC it was their *Year of Science*. As a result, there was a lot of science on TV. What is really nice is that they seem to be continuing that. It just may well be that science is currently sexy and it is vying with history as to what most of the money for documentary-making is going on.

But there are dangers. The worry exists that the programme makers and controllers of TV programmes don't quite appreciate what the public can cope with when it comes to science. We are seeing a change in attitude when we see programmes like *Bang Goes The Theory* on prime time BBC1, covering really good solid science and not just girls in bikinis blowing up caravans. They are doing real science that is aimed at a wide demographic audience.

Chair: We wanted to follow that with a couple of specific questions.

Q35 Stephen Metcalfe: As you know, we are trying to establish what inspires young people to get into

science. How important do you think that programmes like that are, have been in the past, and where do you see the direction of travel with those in the future in inspiring particularly young people?

Professor Al-Khalili: I think they are hugely inspiring. The students who were talking earlier said that science is not perceived as cool. That is changing very rapidly. The science programming that is being made now, particularly on the terrestrial channels, is very accessible. It is tackling solid science, but it is not aimed at the geeks, or, if it is, geekiness is now becoming the new cool. It must be hugely important that students at secondary school and even younger are exposed to some of these inspiring ideas, whether it is astronomy or particle physics, which their teachers might not be able to allow them access to otherwise.

Dr Aderin-Pocock: I totally agree. Programming has big potential. One of the things I heard recently at the BBC is that science is the new cookery. There was a plethora of cookery programmes a little while ago. They want to do the same with science, so we'll see how that works out. We have *Horizon* and *Bang Goes the Theory*, so we have some good solid science programmes, but we also need to have programmes where scientists appear incidentally. So we could have a space scientist in *EastEnders* or something like that. At the moment, scientists are still seen as this rarefied breed that doesn't really interact with the rest of society. We need to be seeing science in everyday life. We have a good set of programmes which are showing science and people doing science, but we need to show science as part of society as well. That is remiss at the moment.

Q36 Stephen Metcalfe: If we then focus down on astronomy and physics, how can we improve the way that particularly is shown or raised in the national consciousness? There has been coverage of the Large Hadron Collider and there are some great programmes like *Stargazing Live* and *The Wonders of the Solar System*. What more can the media do and what about the factual media, the way that these subjects are covered in the news? Particularly with the Large Hadron Collider, the world was about to end when it was switched on, but we are still here.

Professor Al-Khalili: That is where we still have some way to go. For me, that was a good thing. It was great that we were talking about whether the Large Hadron Collider was going to cause a black hole that was going to suck up the universe. It got everyone talking. Guys down the pub who would only read tabloid papers were engaged with it. If you can get them hooked on thinking about science, that is a great start.

In relation to things like astronomy and particle physics, particularly where at the moment it is perceived as blue-sky research and we don't have the application, such as the non-stick frying pan that is going to develop out of it next week, it should be regarded as part of our culture, embedded in the same way that art is embedded in our culture. There is still the Jeremy Paxman on *Newsnight* approach, in which you sometimes hear "..and finally, boffins have come up with something". It is seen as an afterthought, a sort of "Get your thinking caps on now. This is going to be difficult. Here comes the science bit." That hasn't changed yet. So it is embedding science, and particularly the inspiring blue-sky science that engages and fascinates, that needs to be done. We need it to be part of our cultural dialogue.

Dr Aderin-Pocock: It is even worse than you say. It is not just, "Here comes the science bit" at the end, but many public figures are quite proud to say, "I know nothing about science." If they said that about history, art or literature, people would be horrified, but they will stand up quite proudly, and say, "Science. Oh, I know nothing about that." To me, that seems very unfortunate. If they know nothing about it, we should be able to give them the ability to learn more. There is still the perception that, "Science is that strange thing which we don't want to interact with and we don't have to interact with." One of the things I try and get across when I give talks, especially to younger kids, is that science is so much part of our everyday lives. Look at the MMR vaccine. All these things impact on our lives and that is science. It is a matter of trying to show the relevance of science.

There is a very scary video, which was done by WiSE—Women in Science and Engineering—and it was asking school girls why they won't consider taking physics A Level. They were saying, "We can't see the relevance of physics. If you study physics, the only thing you can do is become a physics teacher." This is the perception of what you can do with physics. Again, it is widening it out, showing what physicists do, showing what chemists do and showing how it is integrated into society.

At the moment, we still have the wow agenda, that "Scientists are doing this and looking deep into space", but they don't show the relevance of everyday science, and I think we need some of that. It is not inspirational stuff, but it is the stuff that can make a real impact. It is nice to get that across as well. Quite a few people or quite a few children, these days, when they get into a career—some of them—still want to make a difference. If they want to make a difference, if it is all just out "there", they can't see the relevance down here. That is an important thing to get across. We can do it through TV programming as well.

Q37 Stephen Mosley: Can I talk about money for a minute? We have a situation that stem courses are very expensive to run at undergraduate level at university. This is a two-pronged problem. One is that they are more expensive for universities to run, so they might be discouraged from running those courses. Secondly, with the introduction of higher tuition fees, it might result in higher tuition fees for undergraduates. What do you think can be done? Do you think it will have an impact on the number of undergraduates studying scientific subjects and what do you think can be done about it to encourage more people to go and study at university?

Professor Al-Khalili: It is certainly a worry. Of course, we don't know yet whether universities are going to distinguish between the more expensive medicine, engineering or physics degree and those in arts and humanities where you don't need the big laboratories and the equipment. Universities have

always, long before fees, acknowledged that to teach science and engineering is much more expensive than to teach other subjects. They balanced their books fairly because they acknowledged that there is this range of academic subjects that a proper university should make available. I don't see why that situation should change with the fees coming in. A personal view is that I would not like to see higher fees to study a subject that costs more to teach than another. If we must have fees to make up the shortfall in teaching budgets, then despite some subjects being more expensive than others to teach, universities should not be charging higher fees for them.

Dr Aderin-Pocock: I would find that pretty terrifying if that were the case. There are a number of stumbling blocks for people to go into a science career. They have got to have the interest in the first place. Science is perceived as quite hard to do. You could do, perhaps, an easier degree and get a higher outcome. Also, there is the long term. When you get your degree in science, what is your salary going to come from? All these things are working against science. If you have to pay more for a science degree on top of that, I think the numbers will plummet.

The other alternative is that people will take a science degree but then they will go into banking when they come out. You can lose people from the pipeline all the way down. Again, that would be a very scary thought if we were going to go down that route.

Q38 Stephen Mosley: I was going to move on to that subject. I did a degree in chemistry and when I left university, I went into IT. It is a halfway house. It is not quite banking, but I didn't stay and do scientific research. What do you think we can do to try and encourage more science graduates to stay and do proper scientific research afterwards?

Professor Al-Khalili: Career structures are an issue, but I should say, first of all, of course, there is nothing wrong with people having a science background and science training and going into other areas. It would be great if there were more MPs with science backgrounds. I am sure you would agree. Broadly, throughout society, having a better informed society that understands the scientific issues, whether it is MMR, climate change and so on, is a good thing. So it is great that people with science training then go out and enter into other careers.

In terms of encouraging young scientists to stay in science, that is difficult. That is entirely based on what funding is available. If, at the moment, they are hearing the stories that research grants are squeezed, there aren't the post-doc positions at universities in particular areas, and, "If you want to do this, you are going to have to go abroad", of course, it is going to turn them away, even if they are well aware of a possible career path in science.

Young kids, maybe, won't go into physics because they don't see it as a vocation. It is not like engineering, where they know that an engineer does this, but what does a physicist do? Even once you graduate from university with a physics or chemistry degree and you know what path you would like to take in academia, very often I see a lot of my PhD students getting a PhD in theoretical nuclear physics, a highly specialist subject, and then going off to work in IT, or science communication, not always because they want to but because they are forced to if there aren't the postdoctoral research positions. That is just part of the general worry we have about funding of certain areas of science today.

Q39 Chair: What can Government do about that?

Dr Aderin-Pocock: I think that is the challenge.

Professor Al-Khalili: I am sure that many people have said before, as a criticism of the funding cuts, that we look at other developed countries that are pulling themselves out of recession by increasing funding in science because they are seeing that that is important as a long-term solution. Cuts in the science budget could have been a lot worse. We acknowledge that and we acknowledge that particular areas that we were probably very concerned about are surviving, albeit with belt-tightening involved. There is no way other than to understand that the health of society depends on the health of the economy, which depends on healthy science funding.

Dr Aderin-Pocock: There are two points I would like to make but I can only remember one of them at the moment. When people think of scientists, they think of scientists as academics. I am hybrid because I work in academia and industry as well. We should perhaps promote more science in industry. People don't really see industrial scientists, but as a space scientist I work for the third largest space company in the world, part of which is based here in the UK. By putting an emphasis on that, people can see more career development paths and, as funding gets tighter in universities, there is a plethora of things to do.

The space industry is a growing industry. It supports 70,000 jobs in the UK and it is growing very rapidly. It is also seen as a redundancy-proof area. We should be promoting these areas and showing that science is not just in universities. Science can carry a multiplicity of different disciplines. Also, scientists can go into IT, working for the Government and a range of different things. The more we do that, the better.

We must show science as a springboard for many things. I would like many people to stay in science, but, if we get more people going through one end of the tunnel, it means that we will get people going through it into a diversity of jobs at the other end. We must show how you could use science as a springboard for many different things. The very fact of getting scientists in other different disciplines would help a lot as well.

Q40 Stephen Mosley: I agree entirely with that. I always recommend to young people that they do science because it does allow them to do anything. With a chemistry degree, I could have followed any career I wanted to eventually. If I had done media studies or something, you are a lot more limited.

Dr Aderin-Pocock: Yes, that is right.

Q41 Stephen Mosley: This inquiry is looking at getting people moving through a scientific career. We focus and concentrate on scientific research, but do you think we should be looking at the wider picture

as well, and saying, "Science is good to study because it does open those doors and it does give you the skills to do other things later on"?

Dr Aderin-Pocock: I think so, because one of the challenges is that we need to get more people through the pipeline. At the moment, if you think, "I'm just going to be an academic and I don't want to be an academic", then you are going to miss out on some of those people. But, by opening it up, you will get more people going through the pipeline. Some of them will stay in science, but some of them will go into other disciplines, and that can't be a bad thing. My challenge in the area I work in is trying to get people into that pipeline, and anything we can do to help that must help in the long term.

Professor Al-Khalili: Industry also needs to incentivise those who work as practising scientists in the private sector to be involved more in engaging with the public. At the moment, if you think of those scientists who are prominent in the media, they are pretty much all from an academic background. They are all coming from universities or research labs, but the vast majority of scientists and engineers are not working in universities. They are working out there in companies around the country. They find it very difficult to have the time or the encouragement from their superiors to go out and inspire, to talk to the school kids. That is missing. These are the exemplars of what most people would do with a science degree.

Q42 Chair: You would see that as the corporate sector's social responsibility to reach out.

Professor Al-Khalili: I think so; indeed. What Government can do about it, I don't know.

Dr Aderin-Pocock: In terms of industry, they do have a difficulty with the media, because, if you have an industrial scientist going into the media, there is an assumed bias. I don't think you can get round that. These academics are seen as pure and fairly unbiased, but, when you get an industrial scientist, they work for a company and, therefore, whatever they say is seen as influenced by that company. That is one of the challenges, but that does not stop us from encouraging companies to send people out into schools and other places. It is not just schools but supermarkets or whatever. We must get science out there and get science really integrated into society.

Q43 Chair: In your experience, is there a sufficiently strong relationship between the research councils and the Department for Education?

Professor Al-Khalili: Obviously, they will meet at the top, but I am not sure to what extent, beyond chief executive level, for whatever reasons, they have to come together. I don't think there has been enough dialogue. The research councils have a very clear remit. They look after the funding of research in universities.

Q44 Chair: So much of what you have been saying is an overlap between the two functions—the science that you are funded to undertake and your passion for outreach. I am wondering how we can strengthen that. Wouldn't one way of doing it be to encourage a stronger link between research councils and the education departments?

Professor Al-Khalili: For me, that would mean HEFCE, the higher education funding body.

Chair: Lower down.

Professor Al-Khalili: Lower down, OK, yes.

Dr Aderin-Pocock: When I decided that I would start doing science communication, I wrote to a number of educational institutes, saying, "I want to come into your school." They looked at me as if I was mad. If there was more synergy, "We have a scientist who might be very interested in visiting your schools", then that transfer of knowledge would, possibly, be easier to implement. Even at the moment, when I go and do science communication, it is on a fairly ad hoc basis. Someone hears about my work and so I get invited to a school. It would be nice to have a more formal arrangement where an education authority works with a research council, and they send specific people out to specific schools and have an ongoing relationship so it is not just a one-off. You would have a continued relationship and, therefore, establish the link better.

Professor Al-Khalili: It sounds like a good synergy. I agree. I have not probably explored it myself enough, but it sounds like a good way to go.

Q45 Chair: A final question relates to the fact that we are not perhaps in the strongest position in terms of our support for women in science and technology, although there are some very fine activities going on. What could be done to improve the encouragement of women in science and engineering?

Dr Aderin-Pocock: I was speaking about this yesterday. It works on a number of different bases. First, we can talk about role models. At the moment many women don't see women scientists, so they assume that women just don't do science. If you go to places like the Royal Society, the Institute of Physics and the Institution of Mechanical Engineers, the pictures you see on the walls are all of men, so there is a barrier there. We need to demonstrate that women work in science, in academia and industry across the board.

This is a slight generalisation, but I am talking about the relevance, again. Quite a few women, as I mentioned in this video, think, "What can you do with science?" This is not gender specific, but we need to show people how a career in science can work, the fact that you can get a degree in physics and go into a plethora of different careers, and that those careers can be relevant. Some of my work is on climate change. Quite a few young girls are worried about climate change and showing that their career can lead to helping understand that is of great benefit.

Another factor is inspiration, again. All of these things are not gender specific, but you can make them gender specific and encourage more girls to take up the subject.

Q46 Pamela Nash: I know you have pointed out the problems and what we could do to solve them, but in the span of your career do you think the situation has improved? I was pleased to hear from the younger people earlier, who all seemed quite positive about the

role of women in science subjects. Is it your experience that it has improved?

Dr Aderin-Pocock: Yes. There is a very nice example of this. Over the years, people have gone into schools and said, "Draw a picture of a scientist." In the old days, it would automatically be a man, wearing a white coat with pens in his pocket, but these days more and more kids are drawing men and women. So the perception is changing. The challenge is, is it changing fast enough?

Another challenge is child care, as is aptly demonstrated today by me. Especially in an academic career, having a child and putting that boost into your career coincide. One of the reasons why we don't have as many female professors and people high up in industry is because of that clash. Of course, it is a problem in every career, but it is specifically very challenging for scientists. Finding ways of augmenting or helping women during that period so that they can maintain their scientific presence while having a child, or just having a better division in child care for men and women so that it is a joint activity rather than just falling on the woman, would make a big difference. We are seeing more women coming through, but we are still losing them in the pipeline and they are not getting to the higher jobs.

Q47 Graham Stringer: I was very taken by your comment that, if you have a classics or an arts background, you can boast that you don't know anything at all about science. We have not moved on, have we, at all in the 60 years since C.P. Snow had a debate with leavers, when he said that you can't be educated if you don't know the Second Law of Thermodynamics? I am not sure if that is actually true, but you take the point.

Dr Aderin-Pocock: Yes.

Q48 Graham Stringer: What can we do to address that long- established point? Nothing has happened, has it? What would be your remedy?

Dr Aderin-Pocock: People have a fear of science, and that partly comes from school. You know, "Oh, I hated my physics teacher. He didn't make any sense to me", and that sticks. It is an ongoing scenario. One of the most powerful things to do is to do it through the media so that people watch science programmes and think, "Hey, I understood that." We have to make it more accessible. We must also improve teaching so that people haven't got that fear of science; science is accessible and science is an enjoyable thing, like poetry, arts and history.

Science had its heyday when everybody wanted to talk about science, such as in the time of Faraday, with people going into lectures and hearing about it. It would be nice to create that environment again. Perhaps we are on the cusp of that. The BBC having a *Year of Science* and trying to get science out there engages more people and draws more people in. But we need to do a lot more of it and on a wider basis, because, sometimes, even though we are publicising science, we are only speaking to a very small percentage of the population. We need to get science, as I say, into *EastEnders*, not in a scary way where they are blowing up the world or something but in a more accessible way so that people know that science is part of everyday life.

Q49 Stephen Metcalfe: I have one question very briefly. Going back to the public perception of science, do you think it is important that either there is consensus when science is being presented on television, or is it important that both sides of the argument are put? Which do you think the public is more reassured by and can engage more with?

Professor Al-Khalili: What scientists have to get across is the idea that science is not about certainties. It is not about facts. On the other hand, the programme makers and those in the media also have to understand that, just because something is not certain, it does not mean 50:50. It doesn't mean that you give equal voice to the 95% of climate scientists who are saying that something is changing in our climate to the few who are sceptical of it. We saw it, of course, with MMR a few years ago. In fact it was the complete opposite because the NHS and scientists were saying, "It's a load of nonsense" and stood back rather than engaging with the public on the subject. So, yes, of course, if you don't have the two sides of the argument about a particular issue, the perception will be that it is a conspiracy, it is a done deal and they are trying to brainwash us. But equally, giving 50–50 weighting is wrong.

Dr Aderin-Pocock: I totally agree. We need a better understanding of the scientific method. It is a classic here. In newspapers you can read, "Caffeine causes cancer" or "Caffeine stops cancer", because people pick up on tiny bits of research and they publicise them. People need to understand how science works. People's ideas of science are evolving, because in the past it was, "Science says this." So it was, "Oh, right, science says this", but now we are saying, "We are not sure. We are exploring. We are discovering", and that is the process of science. It is not, "This is the case." We need to take people along in that evolution because they don't quite understand what is going on. They just think, "Well, scientists don't know what they are talking about because sometimes caffeine causes cancer and sometimes it does not."

Q50 Stephen Metcalfe: But who should arbitrate? Who should the public trust to say, "Actually, it is 95% of scientists who believe that there is climate change and it is only 5% who are sceptical of this"? My concern is that the popular printed media doesn't want to portray that balance. They are not a good arbiter because they want to sell newspapers.

Dr Aderin-Pocock: No, they are not. They are not a good arbiter, but they are the voice that the public hear. Perhaps we should have more scientists working in newspapers, which is this pipeline idea. Then you could make it quite exciting but yet keep the balance, because at the moment the balance is totally not there. As a result, the public have a very odd perception of science because it just seems to be all over the place. People who are interested will dig deeper and get a better picture, but how many people have the time to dig deeper? So it is trying to get it out there to a wide audience but keep the balance. That is a very hard

thing to do without infiltrating the newspapers and trying to get the balance right from the start.

Chair: Thank you very much for your evidence. It has been extremely useful. We are going to move on to our third panel. We hope our child care facilities have worked out.

Dr Aderin-Pocock: I will go and find my baby.

Chair: Thank you very much.

Examination of Witnesses

Witnesses: **Professor Dame Jocelyn Bell Burnell**, President, Institute of Physics, and **Professor Roger Davies**, President, Royal Astronomical Society, gave evidence.

Q51 Chair: We now move on to the people who are in charge of some of the issues that we have dealt with today. I am pleased that both of you sat through the evidence sessions because it might inform some of the exchanges. I want to start on a broader issue, if I may. In the written evidence that we have had for the inquiry, there appears to be a lot of ongoing baggage from the troubled times of the STFC. Has the research community put all that behind it?

Professor Bell Burnell: The relationships between STFC and the academic research communities have been atrocious in the past but are considerably better now. STFC has made considerable efforts to involve and inform people. The situation is an awful lot better now than it was.

Professor Davies: I would concur with that. At its formation in 2007 there were a lot of challenges that that organisation faced and it did not handle them particularly well. In particular, it did not consult with its community very well. Therefore, it did not use the resource available. That has changed. There is a much wider structure now for consultation. It has to be said that that is good. However, it also has to be said that the consultation isn't always listened to.

Q52 Chair: During the 2009 prioritisation programme around the recent allocation process, did the STFC properly engage, in your view, with the learned societies?

Professor Bell Burnell: The Institute of Physics has had several useful meetings with senior members of STFC, particularly recently. It is a lot better than it used to be, but there has been a real history of suspicion and bad feeling that they have had to overcome.

Professor Davies: Specifically, with respect to the 2009 prioritisation, at least the Royal Astronomical Society did not have a direct role to play in that. However, we do sponsor a group called the Astronomy Forum, which is a mechanism through which heads of astronomy, groups and departments in the country can meet with senior STFC staff, and that works very well. That has become a really useful conduit backwards and forwards between the research councils and the community. That is nothing to do with the 2009 priority exercise but it is, nevertheless, a very good conduit. Those things have improved substantially.

Professor Bell Burnell: A related issue is the membership of the council of STFC. Initially, there were very, very few scientists on it. There were huge protests from the community. A few more were added. It is fair to say that the community, probably, feels it is still too light on scientists.

Professor Davies: I would agree with that and add one thing. As a result of the Wakeham report, a couple of science members were added to the council, but the most recent members who are being sought, again, are not scientists. There is a minority of scientists on the council which does compare, in a confusing way, with all the other research council memberships.

Q53 Chair: We understand that sometime in the not-too-distant future there will be a new chief executive appointment. What would you have on your wish list of changes in terms of his or her relationship directly with researchers and particularly with learned societies?

Professor Davies: The job of the chief executive of the STFC is a very difficult one. It is an extraordinarily broad portfolio of interests, covering essentially the whole of science. It is a tough call for anybody. There are some aspects of the structure that are always going to be difficult to manage because you have a large standing army of laboratory people who are employees of the STFC, while holding the stewardship of a big area of UK physical science. For me, it would be good to have a chief executive who probably is based in physical science, because that is where the facilities are. Although they are used by a range of scientists, they use the expertise of physical scientists. So it would be a physical scientist who can be effective in advocating the programme of the STFC upwards to the Government, within BIS and so on, and also who is effective at communicating what needs to be communicated down to the community.

Professor Bell Burnell: I don't think I have anything to add to that.

Q54 Stephen McPartland: Professor Davies, what do you think of Professor Mason's assertion in the evidence that he gave to the Select Committee in January that there has been a deliberate over-investment in astronomy during the last decade?

Professor Davies: As the Royal Astronomical Society said in its written evidence, we don't recognise this as reality at all. It is a complicated question, of course. About a decade ago the UK joined the European Southern Observatory. That does require an up-front payment to get in, as it were. We had access to the facilities of that observatory immediately, so the back investment that the other partners had made requires that you pay an up-front fee. That is spread out over about 10 years. However, unless you interpret that as an over-investment, which I don't think you really can, there is no evidence at all anywhere, in any paperwork that I can find, that there has been a

deliberate plan to expand and, therefore, now contract the subject.

Q55 Stephen McPartland: Do either of you believe that, with the publication of the STFC delivery plan and the Budget settlement, there will be any vulnerabilities in astronomy or physics?

Professor Bell Burnell: Yes, probably rather too many. The biggest ones are our reputation both abroad and with our young people. We are finding a lot of our recently graduating grad students are heading to Australia because Australia is putting a lot of money into science at the moment. In Britain, it is doom and gloom. That is probably partly the way we are describing these cuts, and I don't know that we are doing ourselves a service. There is a problem for the reputation of science with our own young people and there is clearly a major problem with our standing internationally. We are not reliable, we pull out with no notice, we do this and we do that. We really need to take a lot of care there. Those are areas that I see as particularly significant and ones that, perhaps, we overlook if we start delving into the figures of who is getting how much.

Professor Davies: I would certainly concur with that. I would add that there are some threats to major future programmes that people have been building towards. The two I would highlight are the Square Kilometre Array and the European Extremely Large Telescope. In many ways the UK community has built a strong base from which to participate in these programmes, and the current situation means that many of the teams working in preparing for those projects and establishing our strong base are funded only for a few months or a year at a time. Of course, this makes us hugely vulnerable. We have a strong position, but we have a strong position because we have excellent staff who are doing very good work that the other partners in these enterprises would like to do themselves. If we cannot retain our excellent staff because of short-term funding, this is going to mean that we will lose that advantage.

Professor Bell Burnell: Research staff are extremely mobile internationally and they will go where the money is, and they can go very readily. I would also want to highlight that the narrowing of the programme in particle physics that is going to happen, or is planned to happen, as a consequence of the cuts means that we have only a single focus. It is very dangerous to have all your eggs in one basket, and that is effectively what we are going to be doing. It does not, I think, provide a healthy diversity that will allow for future developments.

Q56 Stephen McPartland: Do you think that the STFC is doing all it can to mitigate the impact of this Budget settlement?

Professor Bell Burnell: There is some craziness that they still haven't worked through. They have had to do a hell of a lot of rethinking in a very short time. I don't think all of it is thought through yet. In fact, although they have tried to and intended to, and gone about it in quite a sensible way, they are suffering cuts in staff at the same time.

Professor Davies: Yes. I would pick that point up. They are trying very hard to get this right. In particular, the staff on the ground are really struggling to cope with what needs to be done in terms of cutting back in administration, for example. I would not wish to suggest that they are not doing other than the very best job. There are some areas I mentioned where scientific advice has been sought and groups have been empanelled to give advice. Sometimes panels have been advising on process, for example, rather than on scientific direction. Somehow, some of these things tend to get altered after the advice has been given. So a panel is put in to advise on a particular issue, it gives its advice, priorities 1, 2, 3, but then, at the end, it comes out 2, 1, 3 or some other priority list. That, clearly, is not the best way to go about things, in my view. Of course, that further undermines confidence in the community in both the process and the institution.

Q57 Graham Stringer: Atrocious but improving in terms of the relationship. If atrocious is zero and perfect relationships are 10, where is the relationship at now?

Professor Bell Burnell: Six or seven.

Q58 Graham Stringer: So there is still quite a way to go.

Professor Bell Burnell: There is a legacy, you see. There is memory.

Q59 Graham Stringer: The STFC have improved their consultation. The university of Manchester, certainly in their written submission, told us that they did not consult about focusing their investment on their own facilities. Is that right?

Professor Bell Burnell: I don't know the answer to that one.

Professor Davies: I could not speak definitively on that one either. I did point out, however, that it is a natural conflict of interest in the way the organisation is structured.

Q60 Graham Stringer: Yes. That was in your evidence, is it not?

Professor Davies: Yes.

Professor Bell Burnell: Yes. I suspect, as a decision, it is not good for science. You need the instrument building close to the people who are doing the research. The two interlock so intimately.

Professor Davies: Could I add one thing to that? I probably slightly missed your point. If we are on the subject of technical innovation and instrumentation and that being focused in the labs, that came as a bit of a surprise, I think it is true to say. There was a very negative reaction in the community. That negative reaction is rational in that one of the reasons why we are at the forefront in many of the areas where we are at the forefront is because we have developed skills and expertise that others don't have. That is the nature of doing research. That is what enables you to do research. The way you sustain that is by training students. If you cannot train students in instrumentation because that is all done in the national labs, that activity will ossify. The academic

community is very alarmed by the prospect that that now might happen.

Q61 Graham Stringer: That has answered one of my next questions. You think it is going to have a very negative impact on research within university departments.
Looking at the other side of it, what is it going to do for the future of accelerator beam technology within the STFC facilities themselves? Are they going to really benefit from this or will they lose?
Professor Bell Burnell: It is the university departments that have the people who are really skilled at building the equipment to go with accelerators, on accelerators and attached to accelerators. The really skilled people are there. If that doesn't happen, if those people leave and go to Australia or whatever, Britain is the loser.

Q62 Graham Stringer: Let me see if I really understand what you are saying. You are saying that, by focusing money within the STFC facilities, those facilities themselves are not going to benefit because the supporting or collaborating staff within the universities may disappear and, therefore, nobody benefits from it. Is that a fair interpretation?
Professor Bell Burnell: No. I think we may be talking at cross-purposes. I am talking about the instrument development to be done in STFC establishments, not in universities, to be done in-house.

Q63 Graham Stringer: Yes, that is right. I am trying to work out what the implication of that is, both for the university research facilities themselves and for the STFC's facilities. What I understood you to be saying was that it would be bad for the universities, but because they may evaporate—disappear—that investment might be wasted in the STFC facility. Is that right or have I misunderstood it?
Professor Bell Burnell: Yes. I am sorry. We are now on the same wavelength.
Professor Davies: I would add to that that almost everything we do in these spheres is international. If you are going to innovate and lead, you need to gain the confidence and partnerships of your international collaborators. Generally speaking, this is done through university groups but not exclusively. The laboratory staff have a very important part to play in the development of this area, but, without the role played, essentially, by scientific entrepreneurs in the universities, then their future will also be in jeopardy because the new projects, the new opportunities, which are all international, will not come along.

Q64 Graham Stringer: You keep answering my questions just before I have asked them, which is very clever. My next question was going to be, after LHC, what impact are these proposals likely to have on our future involvement in that area of particle accelerators? You have sort of answered that question by saying it is bleak.
Professor Davies: I think so. We have covered that, haven't we?

Q65 David Morris: Professor Davies, the UK currently has a leading role in priority astronomical projects such as the European Extremely Large Telescope and the Square Kilometre Array. Would you say that this is under threat?
Professor Davies: It is under threat in the way I described, in the sense that we have not committed to either of these projects yet. We have not been asked to quite, but the international arrangements are getting very close to that stage. If we are not able to commit at the time that we are asked, then that will be a major setback. We have leading teams. We have the opportunity to take the lead in some areas. Obviously, if we are tardy in committing, that lead will evaporate. It won't evaporate instantly but it will go. Our staff will move. Other countries will say, "We could do that bit." We will suddenly find that, instead of having a leadership role and doing the interesting things that, maybe, lead on to the next thing, we are back doing something less interesting and not in the lead. So the ability to commit to these projects in a timely manner is fundamental to the health of the subject.

Q66 David Morris: What would you say the benefit of these projects has been to the UK so far?
Professor Davies: These particular projects?
David Morris: Yes.
Professor Davies: The SKA is a very interesting one. Being radio astronomy technology, there are many connections with communications, telecoms and so on. There are possible developments in Cornwall to do with the Goonhilly site and so on that are directly related to advances in that area. In the area of optical infrared astronomy for the E-ELT, the UK has major activities in sensor design and production. Also, many of the types of technologies that are produced in that area have been used in medical applications, for example, breast cancer screening. There are topics going back to the radio area in security such as terahertz imaging where you can see a plastic gun as you go through a scanner. There are large areas of pretty advanced technology, usually, where spin-offs from the kind of work that is done for these technological areas have real world applications.

Q67 Roger Williams: It has been said that astronomers are trying to have their cake and eat it. I expect they are like most other people in that. Would you accept that, when it was decided 10 years ago that the UK joined the European Southern Observatory, that meant that other projects would have to go? Should we not accept that ESO membership has to be paid for by withdrawing from other projects?
Professor Bell Burnell: Other projects did go. They have gone. The snag is that we are now getting more rounds of cuts. In a sense, we have paid for ESO through closing things.
Professor Davies: There was a plan, in fact, made at the time. It required us to withdraw from the Anglo-Australian Observatory, which we have now done, also to reduce our share of the William Herschel Telescope, which we have now done, and also to cut down on the operations cost of the UK Infrared Telescope in Hawaii, which we have now done. It is not true to say that that plan included, for example,

the closing of all northern hemisphere observatories, which is what we are threatened with.

Q68 Roger Williams: Professor Mason argued that if we are going to stay in front of the pack we have to concentrate our resources. Do you agree that we should, for instance, look at the Gemini project and the Isaac Newton Telescopes as facilities that might have to stand aside while we concentrate on the ESO?
Professor Bell Burnell: I think you can be too concentrated. Since we have joined Gemini, the effort put into running both the UKIRT and the Isaac Newton Telescopes have drastically reduced. What has been really inspiring to me is how ingeniously those telescopes have been used by UK astronomers at minimal cost. The way that they have saved a lot of money up till now is by having a suite of instruments that you don't change basically. You have a standard piece of kit on the telescope and, therefore, you reduce the staffing, changes and everything. Fantastic science has come out of that. While it is important that you have a goal, a destination, somewhere to aim for, it is bad policy to focus only on that. You need to keep a bit of diversity, a bit of hairiness on your string that leads you out of the maze.
Professor Davies: Your question was, should we look at these things? The answer is that we look at them all the time. Immediately before joining the European Southern Observatory, we closed the Royal Greenwich Observatory. We look at our programme all the time and think, "This is the amount of resource we have. Where is the best way to get the best astrophysics done?" That involves tough decisions, but it is done in a way that the community has built for itself. Some people are disappointed but we don't shoot each other.
There are other aspects here. The withdrawal from Gemini was one of the things that seriously damaged our international reputation in the way it was done. However, it's done. We are pulling out from 2012. If we further close the other northern hemisphere observatories, there are a number of serious consequences for our competitiveness internationally. This is a very international subject, and UK people are going abroad and people from abroad are coming to the UK to work all the time. That is a very healthy thing. It means that the people teaching in UK universities have a very broad experience, for example. If we only have the ability to look at half the sky, we will be much less attractive at drawing people in internationally because they will see that they cannot make their careers successfully here.
Furthermore, there are real astrophysical issues to be looked at. There are unique objects in the northern hemisphere. The nearest galaxy to our own, the Andromeda Nebula, which the young people behind probably have seen with their naked eye in the sky—it is the most distant object you can see with the naked eye—is 2 million light years away. That object is only available in the northern hemisphere.
There are other unique objects in the northern hemisphere. If you want to follow up radio observations that you might do at Jodrell Bank or satellite observations that we get through our membership of the European Space Agency, these all require access to the whole celestial sphere. So only having access to one hemisphere is a serious disadvantage. Retaining access to the northern hemisphere, through the La Palma telescopes, is a very high priority and was identified as such by the advisory bodies that I mentioned earlier.
My final remark on this point is that, in relation to the other members of the European Southern Observatory who are comparable to us, the UK is, by some margin, still the most productive European astronomical community, but the other big countries, such as Germany, France, Italy and Spain, all retain access to northern hemisphere facilities for the very reasons that I have given you. Therefore, again, if we don't have that, we will lose our competitive position.

Q69 Roger Williams: You are arguing very strongly to negotiate some access to the northern observatories.
Professor Bell Burnell: Yes.

Q70 Roger Williams: Even though we are still participating in the ESO.
Professor Davies: Yes.

Q71 Roger Williams: What is the case for the STFC to continue funding other smaller ground-based facilities such as the Liverpool Telescope?
Professor Bell Burnell: That one is used a lot by schools as well as its own programme. It is also used for some very exciting work on gamma ray bursts, for example. There are things that you don't need an enormous telescope for and it is actually a waste of time on an enormous telescope. You also have an issue of how you feed the big telescope. Quite often, when countries do a big telescope, they have a suite of little ones saying, "Oh, that's a curious thing. We should get the big telescope to look at it."
Professor Davies: It is a mistake to see the Liverpool Telescope in isolation from the other research facilities on La Palma. They all work synergistically together. There is a property of optics which means that bigger telescopes only look at a tiny patch of sky, whereas a smaller telescope can look at a much larger patch of sky. If you want to do a survey, you are often better off not using the very biggest telescope.

Q72 Gavin Barwell: You have covered some of what I was going to ask about already, which is in relation to access to optical infrared facilities in the northern hemisphere. I want to probe a little bit more on that. Can you clarify exactly what the position is? Several times you have used the phrase "if we lose that access". Is the decision taken on that? What is your understanding of the factual position about whether UK-based researchers will still have access to observations, outputs and data from these facilities?
Professor Davies: My understanding of the default plan, if nothing changes, is that the UK's access to these facilities will be withdrawn in a period between 2012 and 2014, depending on which one you are talking about.

Q73 Gavin Barwell: What impact will that have on astronomical instrumentation R and D beyond the observational data that you have already talked about?

Professor Davies: That is an interesting question. If you take, for example, the William Herschel Telescope on La Palma, one of the aspirations for using that telescope in the future is to follow up a satellite in which the UK has played a major role called Gaia. It is a European Space Agency satellite. That satellite is designed to map out the structure of our Milky Way in order to understand how it formed. In order to get to the scientific answers that we are trying to achieve using that satellite, we need to do a spectroscopic survey of many of the objects that it will look at. An instrument that could do that would be ideally suited for the future use of the William Herschel Telescope. This is something, again, where the UK has a history of being in the lead. If this were allowed to go forward and be funded, this would retain that leadership.

Q74 Gavin Barwell: Since you have covered most of what I was going to ask before, I want to pick up on Roger's question, if I can, in terms of what the taxpayer is getting for its money. Looking at the figures that we have been provided with, the STFC resource and capital spending on astronomy and particle physics, the resource spending is going up on particle physics from about £117 million in the current year to just under £150 million at the end of the spending review period. That is quite a significant increase there. On astronomy, it is going down from just over £75 million to about £69 million. So there is a cut there.

Professor Bell Burnell: Are you including capital or just resource spending?

Q75 Gavin Barwell: No. That is resource spending. The capital cuts are quite significant. Can you just explain this to my constituents? The picture I have from you today is that, even on particle physics, despite those resource increases, you have used the phrase, "We are putting all our eggs in one basket and that is not necessarily a sensible thing to do." On the astronomy side, not only are we losing the northern hemisphere optical and infrared capacity, but you were also saying that there are doubts about UK participation in some of the key ESO projects, the E-ELT and the SKA. It is still quite a significant sum of public money that has been put into this project. What are we getting for that money? How is it that there is such a contraction given that the spending reductions, while they exist, are not huge?

Professor Davies: Maybe I should start. Let me take the E-ELT and the last bit of your question. We need to recognise that the spending review that we have just gone through did produce an outcome for our areas which is as healthy, perhaps, as we could have hoped for. However, the capital contraction, even though it is as healthy as we could hope for, is a flat cash settlement. This has an effect in the range of 10% to 20% reductions over four years. This is compounded by the fall-out from 2009.

Going into this spending review, these subjects have been cut by about 35%. On an average of 10% to 20%, you are talking about a factor of 2 cut between 2007 and 2012. We specifically mentioned that factor of 2 is in the number of researchers who would be funded on grants. So there will be a very significant cut.

You asked, what are we getting? What we are getting is a research endeavour in this area that is world leading, second only to the United States, in citations and so on. We are very well regarded and established and we are getting the range of things that come along with that. Notably, we have talked a lot this morning about outreach, about inspiring school students and so on. Furthermore, there are a lot of technical developments. I would say that the economic value in the technical developments is potentially very high and it is the kind of high value work that the UK, probably, will aspire to in the future for its economic future.

Professor Bell Burnell: One of the interesting statistics we have is that, of undergraduate physics students in Britain, 90% say they have come in because they are interested in particle physics or astrophysics. It is a tremendous pull for the general public as well. You can run astronomy evening classes even without advertising them. I know because we have done it. There is a tremendous interest in the subject. It is perceived as, and I think actually is, a good way into science for those who are scared of science.

To pick up on some conversations that took place in the previous section, I have an interest in poetry with a space or astronomy basis. Doing talks on this, I get audiences that are 60% female and 40% male. Doing a straight astronomy talk, I am lucky if I've got four females in the audience. It is reaching a different public. That is one of the great strengths of astronomy. Both astronomy and particle physics, these big ideas, are incredibly attractive to people. When they come into science, if they are students, they don't necessarily stay in astronomy and particle physics. They go into other areas well. It has an enormous draw.

There are also many spin-outs from particle physics. Clearly, the radiation treatments for tumours and things, particularly, for instance, the proton and heavy ion stuff that you can get on the continent that we haven't got here yet, is really a much better treatment for tumours than the electrons.

Q76 Gavin Barwell: On Professor Davies' point, I want to get to the bottom on the numbers. Is the thing that is driving this contraction in the range of areas that the UK will be able to participate in the resource reductions or the capital side? What is it that is driving, for example, the removal from the northern hemisphere?

Professor Davies: That is the resource, I think.

Q77 Gavin Barwell: In terms of sums of money that is causing this situation, they are not very large sums of money.

Professor Davies: It is not.

Professor Bell Burnell: No.

Q78 Gavin Barwell: If you look at this budget on resource on astronomy, the figures I have in front of me show we are at £75 million and we are going down

to £69 million. What sort of level would it have to be at to not lose this capacity?
Professor Davies: It is £2 million to £3 million more.
Professor Bell Burnell: It is a banker's bonus.

Q79 Graham Stringer: In relation to that £2 million or £3 million that has gone, are you saying that that is a hangover from the original underfunding by, from memory, about £80 million?
Professor Davies: Yes.

Q80 Graham Stringer: That £2 million or £3 million hangover is not really the structural part of the latest settlement, is it?
Professor Davies: That is a fair point. A lot of this is left over from 2007 and 2009.

Q81 Stephen Mosley: We started off this morning talking to the sixth formers who explained to us what drew them into physics and science. A couple of times the National Schools Observatory was mentioned. You have mentioned the Liverpool Telescope as well in your submission since then. How important do you think those telescopes are in developing the links between the research community and the education community?
Professor Bell Burnell: Value for money. They are not wildly expensive to run and they are a fantastic link.
Professor Davies: Yes.

Q82 Stephen Mosley: Within your written evidence you also talk about the STFC reducing funding to produce other material, for instance, posters and leaflets, etcetera.
Professor Bell Burnell: Yes.

Q83 Stephen Mosley: How much of an impact do you think that will have on schools and on encouraging people into science?
Professor Bell Burnell: The IOP will do what it can but it doesn't have the same resources. STFC used to have a very good science in society programme. It is still there but at a considerably reduced level.
Professor Davies: If you look at what other research councils have done in order to accommodate to finances, STFC have tried hard to retain as much of this as they can because they know it is an important area for them. I would not be quite so negative. Obviously it would be good to have more and do more, but they have tried to prioritise this area.

Q84 Stephen Mosley: In your written evidence, Professor Bell Burnell, you do mention about establishing a Virtual Institute.
Professor Bell Burnell: Yes.

Q85 Stephen Mosley: Could you explain a bit more about that and whether you have had any discussions with the STFC or how is that proceeding?
Professor Bell Burnell: It is not up to the Institute of Physics to do that. It is up to the individual researchers. I believe a submission has gone in but I haven't heard the outcome.

Q86 Stephen Mosley: As a bit of background information, how will this Virtual Institute operate and work?
Professor Bell Burnell: It is in the area of overlap of astronomy and particle physics, so it is concerned with things like the very early universe, the nature of dark matter, neutrino astrophysics and areas like that. That is a very strong area in Britain. We are particularly good at that. As I understand it, the Virtual Institute would try and gel and cohere the work in that area. That is about as much as I know about it.
Chair: Thank you very much, Dame Jocelyn and Professor Davies, for wrapping up what has been a fascinating morning. Several people were critical of people with interests in broader issues than just science. I notice that you, Dame Jocelyn, referred to your interest in poetry. My late father taught me a wonderful little ditty, which I am not going to recite today, but it starts, "Scintillate, Scintillate, Globule Vivific." You can imagine what the rest of it is. It is hugely important that we get the right messages across from this inquiry and we are extremely grateful for your evidence. Thank you very much.
Professor Bell Burnell: May I say on behalf of both our professional bodies how very grateful we are for this Committee? We feared, come the election, that this Committee might cease to exist. It is so encouraging that all of you have stepped up to the plate and, clearly, are working very, very hard on these important issues. Our thanks to this Committee for your work.
Chair: Thank you.

Wednesday 16 March 2011

Members present:

Andrew Miller (Chair)

Gavin Barwell
Stephen Metcalfe
David Morris
Stephen Mosley
Pamela Nash
Graham Stringer
Roger Williams

Examination of Witnesses

Witnesses: **Professor Phil Allport**, Head of Particle Physics and Director of the Liverpool Semiconductor Detector Centre, University of Liverpool, **Professor Mike Bode**, Director of the Astrophysics Research Institute, Liverpool John Moores University, **Professor Robert C. Kennicutt, Jr.,** Plumian Professor of Astronomy and Experimental Philosophy Director, Institute of Astronomy, University of Cambridge, **Professor John Peacock**, Head of the Institute for Astronomy, University of Edinburgh, **Professor Steve Rawlings**, sub-Department of Astrophysics, Oxford University, and **Professor Andrei Seryi**, Director, John Adams Institute for Accelerator Science, gave evidence.

Q87 Chair: Good morning, gentlemen. Thank you for attending. With a panel of six, we have to be careful so that we do not end up repeating each other. At the end of today, if you feel that there is any additional information you want to feed in that you have not have a chance to comment on in what is quite a tight session, please feel free to write to us again. I know some of you, of course, but, for the record, I would be grateful if you would say who you are and where you are from.

Professor Allport: I am Phil Allport from the university of Liverpool. I am a particle physicist.

Professor Bode: I am Mike Bode from the Astrophysics Research Institute, Liverpool John Moores university.

Professor Kennicutt: I am Rob Kennicutt from the university of Cambridge. I am the Director of the Institute of Astronomy.

Professor Peacock: I am John Peacock. I am the Head of the Institute for Astronomy, university of Edinburgh.

Professor Rawlings: I am Steve Rawlings from the university of Oxford.

Professor Seryi: I am Andrei Seryi, the Director of the John Adams Institute for Accelerator Science.

Q88 Chair: As you know, we are looking into the broader issues to do with particle physics and astronomy and the support for it in the country. We have had a number of extremely interesting sessions so far, not least with six young people who performed brilliantly last week and set the stage for today. Now we are into some of the difficult relationships between the various parts of the community and the STFC. Relations with the chief executive and the STFC have been, to say the least, a little bit difficult since 2007. Some of the evidence we have had suggests that things are getting better. Is it now time to turn over a new leaf and move on?

Professor Peacock: Let me begin by thanking you for the chance to be here today. We know we are very lucky to work in inspiring subjects like astronomy and particle physics, and we don't want to come across as ungrateful, but the fact is that the community has been very unhappy since the formation of the STFC and the Comprehensive Spending Review at the end of 2007. We have seen massive cuts. Domestic spend in astronomy is heading to be down by almost a factor of two compared to what it used to be. That is bad enough, but it was felt almost universally that the STFC was not explaining to us how these cuts had come about. It was making decisions about what cuts would be implemented without consulting the community. That is a terribly low base to be starting from.

From that point of view, things have got better. A new network of consultative committees was set up; so the cuts have been decided in a democratic and consultative way. We have just had the next Comprehensive Spending Review settlement, which was less bad than many people feared. Overall, clearly, things have improved.

It should also be said, though, that a lot of these improvements are generally perceived as having been implemented by senior staff in the STFC or members of the STFC council. When you look at the issue that you referred to right at the start, the culture at the top of the STFC that comes from the chief executive, there is still deep unhappiness. You could speak of a breakdown of trust that has developed and hasn't really changed.

Q89 Chair: In your evidence, you use phrases like "'inward-looking", "focuses on its own 'in-house' research facilities" and "treating academia as a 'secondary tier of its business'." What can be done to rectify that?

Professor Peacock: These things are going to have to be addressed by the next chief executive.

Professor Allport: I would echo what John has just said. The things that have been positive in the preparation, for example, of the Comprehensive Spending Review and its aftermath, particularly through a sub-committee of council working with the chief executive, are that there was much more communication with the various communities. The process of preparing the CSR was something that the communities felt they owned much more than has been true previously and certainly wasn't the case in 2007.

The other thing is that, particularly through the chief operating officer and the director of programmes, there has been a lot of communication after the event with the communities, discussions about what the possible implications are and some genuine debate about how one tries to move forward, given a settlement which, compared with 2007 and the environment we were in, was towards the top end of what one could reasonably have hoped for in what has been a very difficult spending round, which we fully appreciate.

Professor Bode: There is no doubt that the chief exec's job is an incredibly tough and demanding one. The STFC is an exceptionally complex organisation. There is a lot of tension between the basic science, for example, and running facilities that service other communities, the campus ventures and all those other things. There is a perception in the community that there has been a disconnect between the level that Phil was talking about in the STFC, who have been interacting with the community, and the chief executive. The perception is—I am sure we will hear more about this later on, and members of the Committee may know more about this and the way this works—that the chief executive has been more upward facing into Government, which is obviously a vital role of the chief exec, but he has not been pushing the basic science as much as the other parts of the STFC remit, certainly not as much as the community would have wanted.

Q90 Chair: Professor Kennicutt, in your evidence you suggested that there is a "leadership vacuum". What are your expectations of the leader of the STFC? Are there particular things that you hope the next chief executive will do differently?

Professor Kennicutt: That is a good question. On the second part of the question, in fact, the STFC charged a working group to define the desirable list of traits for the next chief executive. I believe that committee was chaired by Marshall Davies and the report was issued in November. It is an excellent document of which we are aware and I would concur with it. In terms of my own outlook, part of the reason that the job is so challenging is that unlike councils in many other countries—for example, in the United States, where I worked for many years—the entire process of community consultation, prioritisation and implementation of decisions was all done within the research council, unlike the US, where you have an entirely parallel set of prioritisations done by the National Research Council, which reports directly to the US Congress.

My colleagues here ask me about this often. I think the system here is much more efficient and it is the preferred system when you have strong leadership, but for it to work you need someone with a scientific background who understands the broad spectrum of issues. You need a process from the council on down that is utterly beyond repute in terms of conflict of interest, in which consultation is an apt development and in which there is accountability in terms of the feedback between the community and the executive. I realise those are somewhat general qualities.

Q91 Chair: But, for that to work, there would have to be almost total transparency in the process.

Professor Kennicutt: That is right. Of course, you cannot have complete democracy, especially in a difficult spending environment like this. We understand that.

Professor Rawlings: It might be important to analyse why the changes that have happened recently have been successful. I do not want our community to come across as a bunch of whingers. We are very appreciative of the changes that have happened. We all agree on this committee that the outcome of the spending review 2010 was as good as we could expect. So, clearly, lessons have been learnt. We appreciate that at the start of the STFC there were probably peculiar problems that have worked through the system. An analysis of how that has changed would be very positive for appointing the right person to the next chief executive role.

Q92 Pamela Nash: We are aware on the Committee that the numbers of studentships and grants that have been awarded by the STFC have decreased quite significantly over the last few years. Have any of you seen any evidence that this has put off young researchers from staying in the UK or, indeed, coming into the UK to conduct their research?

Professor Allport: Yes. I can speak, perhaps, first for particle physics. One of our postdocs carried out a survey at CERN of those who are currently still employed in particle physics. He found that for those who got their PhD before 2007, three quarters of them, when they were looking for jobs, had been made offers in the UK. For those whose PhDs were after 2007, that number has fallen to a third. The anecdotes are that of this year's crop, almost everybody who is staying in the field is doing so by taking posts outside the UK. That does feed back into people's expectations. Certainly, in the last round of student interviewing that I was involved in for PhDs, a number of people were expressing concerns about the prospects for careers at the end of the process. It is having an effect and it is dissuading people from going through a process that I, personally, feel provides a very broad training and often leads into areas that are quite diverse from those in which the PhD is taken.

Q93 Chair: Is that data in a form to which we could have access?

Professor Allport: Yes. I can give you the web page produced by Paul Laycock, who carried out the survey at CERN. It is low statistics and it is, of course, a sample of those who responded largely from within CERN. One should not treat it as being something that would stand up in a proper statistical analysis, but it is indicative.

Professor Peacock: I would like to try and clarify something. You mentioned studentships and postgraduate training. There are PhDs funded by studentships and then many of those people will want to go into postdoctoral positions to refine their skills further. So the number of places for PhD studentships has been maintained and that is very good. The

problem now is that the postdoctoral fellowships or research assistantships, which are the next step, have been slashed by a factor of two. In many cases, the best people for the next generation are having great difficulty finding jobs.

I see this in my own institute. Some of our best students struggle to find a position. Their options are to go abroad or to leave the subject. Going abroad is not so straightforward because the PhD system here is different. It is shorter. Really, in a way, a few years of postdoctoral research is needed to round off people's education. It is not trivial, even if we wanted to see all our best people go off to Germany to work, for them to be able to do that. There is a missing generation in danger of developing.

Professor Kennicutt: To reinforce what John has just said, studentships in astronomy may have declined very slightly but the number of postdoctoral positions over a decade has dropped by about a half, I believe. Our concern on this point is the impact this will have. Since there is a delay on impacting the career plans of the PhD students, we haven't seen an impact yet on incoming students. Our fear, of course, is that, if this situation persists, the best and brightest will begin to look to fields other than particle physics and astronomy.

Professor Rawlings: It is also the case of our international reputation. If we could achieve a stable funding environment in this country, that would be great not only for our own students but also for making sure that we attract the most talented people from around the world to come and work in postdoctoral positions. International reputation and stability of funding go together and are very important in this area.

Professor Bode: As well as the postdocs that have declined, the fellowships, which is the natural next stage, have declined as well. The typical career path, which probably most of us followed, is that you go through a PhD, then a postdoc and very often time abroad, which is actually very valuable, but then come back, very often into a fellowship position, which is like a parking orbit for a lectureship in a university. But the fellowships have been reduced considerably as well.

Q94 Pamela Nash: My question was about whether we are losing researchers to other countries. From the responses that you have given me, can I clarify that you think we are losing some researchers to other subjects outside what the STFC is funding?

Professor Kennicutt: Historically, only a fraction of astronomy PhDs stay in astronomy. In fact, we send people to the City, finance, banks and medical spheres. That is considered a good thing, of course. We don't want to change that.

Professor Rawlings: But also into industry and across the economy.

Professor Kennicutt: High tech is the other one.

Professor Peacock: In truth, it is hard to answer because there are big fluctuations from year to year, which nobody really understands. In one year you can have almost twice the number of good applicants and you can't see what has changed. So it will take a while for a pattern to become clear. At the moment all we have is fear, but there are good grounds for it.

Professor Kennicutt: The worry is that the Stephen Hawkings of the future, who are coming up as undergraduates, will move away from the subject, from their chosen research field, in the end, if they fear there is not a job for them. That is the concern.

Q95 Pamela Nash: You have all expressed very real concerns about this. Given the financial climate that we are in and the funding constraints that the STFC is experiencing at the moment, do you think that they should concentrate their funding on teaching and researchers at the moment, even if that is at the expense of other necessities?

Professor Peacock: This is hard. You have to feel big sympathy for the people who have to do this juggling, and perhaps gratitude that it is not your own responsibility, because the facilities that STFC deals with are big, monolithic things, and you don't have the control that you would like.

We are a member of this European Treaty organisation—the European Southern Observatory. If we all had our wish, we would just turn a knob and say, "Look, let's make that 10% cheaper and we will put the money saved into these postdoctoral research positions." It is absolutely clear that it is the investment in the young researchers that has made UK astronomy and particle physics world class. I know plenty of Americans who looked at us with envy in the sense that we have been able, to use the old cliché, to punch above our weight and extract the maximum scientific value from our facilities by funding the people who actually did the science. The fact that that has been cut by a factor of two is a disaster, and we would like to build it back, but we can't just change what we pay to ESO. The ESO subscription is set as a fraction of GDP. Ultimately, you can say that the problem is that the UK is not investing in scientific research pro rata to its GDP at the level of our competitors. Our figure is 1.8%. In Germany, it is something like 2.5%. If that disparity remains, there is always going to be this problem.

Professor Bode: There has been one positive aspect to things recently, in that the grants line from which most of those postdocs originate has been ring-fenced. It is now protected in the Delivery Plan. It should not, therefore, be used as what has been termed "the balancing line" because it is the one part of the cash that is more easily raided—perhaps that is the wrong word—or to balance things up. As John was saying, you have commitments that you can't get out of. The facilities we have now are all very highly ranked. We have now, at least, some guarantee of the funds within the grants line being maintained, although being eroded, presumably, by inflation. One would look to the future, when times get better, as they will do, but one would aspire, as John was saying, to an uplift overall for science in the UK to try and match the investment of our competitor nations. When the uplift comes, the community would prioritise grants very highly and that should be where additional cash should first go. I am sure other colleagues can comment.

Professor Rawlings: That is right, but these young people, the postdocs, always must have access to world class facilities. There is always that tension. To reiterate John's point, maybe the deep underlying problem here is the fact that we are only spending 1.8% of our GDP on R and D, whereas other developed countries are spending a larger amount. That may be the solution to this problem in the long term.

Professor Peacock: It is a long-term solution. In the medium term, I think the STFC still does have some wriggle room. We would like to see it prioritise grants more than it does.

Professor Allport: If you go back to 2005 in the days of DIUS, there was a White Paper which clearly set the ambition to get to 2.5% of GDP. Given that we will not be, we hope, in recession for ever, to have an ambition like that again would send a very positive message out to young people who were thinking of moving into STEM science areas. To look at the re-balancing, this is clearly part of the nearly impossible job that the chief executive and those in charge of the STFC have to manage. It is an over-constraint problem. In my area, if we pull out of CERN, then you, basically, would just shut the door on particle physics as a subject. There has been very tough negotiation. Not only has the CERN subscription been kept fairly constant, but in Swiss francs it has been brought down. Unfortunately, the currency exchanges take things in the other direction. A very tight lid is being kept on the subscriptions, so I do not know that there is too much scope for pushing the subscriptions down much further without starting to damage the facilities to which the students need to have access.

Q96 Roger Williams: Much has been made of the fact that resource funding is going to be maintained in cash values, at least, in the medium term, but probably less emphasis has been put on the fairly substantial cuts in capital expenditure. Professor Mason told us in January that there had been an over-investment in astronomy in the last 10 years, particularly since joining the European Southern Observatory. Do you recognise that, or what is your response to that?

Professor Peacock: A pulse of money went into UK astronomy which was always intended to be temporary. When we joined ESO, we immediately had access to their telescopes that had been created over decades. As well as paying your annual subscription, there was a back payment to buy our share of ownership of those things. Even in 2002, when this happened, you could see a spreadsheet where there was this pulse of several millions a year, which, yes, was over-investment, and it was scheduled to stop about now and it has. The idea that because we joined ESO, we did not need any of our other telescopes is just not the case. In fact, because we joined ESO, I believe that we need our other telescopes more. We want to be the best in the world in this subject, and how can you be that if you just have exactly the same facilities as all your competitors? We need something that gives us an additional edge, and that is why we felt that joining ESO stopped the Europeans taking over, but we needed that to add to what we already had.

Professor Rawlings: As a community, we are willing to give things up, as has been demonstrated by the peer review process that Rob Kennicutt was a central part of, that has resulted in the UK pulling out of Gemini, which was a fantastic facility in both the northern and southern Hemispheres. We understand the realities of the environment in which we are working and we can prioritise.

Professor Kennicutt: Gemini will realise a saving of £8 million per year eventually once the phase-out is completed to the Treasury's approval. At about the time we joined ESO, the Royal Greenwich Observatory was closed. That is a saving of more than £6.5 million, I believe, a year. We withdrew from the Anglo-Australian Telescope, which has saved nearly £2 million a year. Partly through skilled negotiation by the STFC, the costs of many other ongoing facilities are being ramped down. It is important, as I believe someone asked last week in questioning Professor Davies, that we don't want to have our cake and eat it too. We are prepared to close this or even withdraw from facilities. I think the issues that have been raised are more about process and prioritisation in how that is done.

Professor Peacock: On this issue of over-investment—let me just emphasise it again—until the financial crisis that was associated with the formation of the STFC, there was no intention to wind things down. You can look at the planning spreadsheets that have ESO and Gemini on them. There used to be enough money for these and there was a scientific rationale for all of them, but now we have had to make painful choices. The idea that you always knew that this had to happen has no basis.

Q97 Roger Williams: Nevertheless, one of the panel members said that, if we are going to have talented young scientists, then we must have the best facilities for them. Yet it looks like the capital grants to universities will more than halve. Will there be enough facilities of the necessary standard in universities to carry out these projects and attract these young people?

Professor Kennicutt: Some of us addressed this question in written evidence. Certainly, I have a number of concerns, as does the community. A lot of this money goes for building instruments on telescopes. Of course, that funds instrumentation groups that have some of the strongest connections to industry in the UK and enables us to compete in European projects for instruments. Equally so, the kit they are building and the instruments that come out can expand the capabilities of these telescopes extraordinarily. As one example, I know that the William Herschel Telescope has come up a number of times. There is a proposal afoot to build a spectrometer that can obtain spectra for not one object at a time, which is what the Herschel Telescope could do when it was built, but in fact to measure hundreds or maybe even thousands of objects at a time, so you can literally realise with a relatively low-cost instrument an increase in the capability of the

telescope for their application of 100 or 1,000 times. So it is a win-win situation. Indeed, that funding is being squeezed, and there will be detrimental consequences in both of those areas.

Professor Rawlings: It is worrying for the variety of things it covers. For example, our theoretical colleagues require high performance computing. That is also counted as a capital expenditure. Of course, without the theoretical part to add to the observational part, we are not doing our full job. There are serious worries about the level of capital funding.

Q98 Roger Williams: Is there any possibility that there could be other sources of this funding for universities?

Professor Allport: Yes. We are seeking pots from other research councils, for example, and applications go into the European Union, but many of these bodies are looking at grant applications and saying, depending on the topic, "Shouldn't this be being funded from the core source for particle physics and astronomy funding in your country?"

In my area, which is particle physics, we do a lot of detector development in the UK. We have built quite significant parts of what has ended up in the major experiments at CERN. In fact, the UK has some very high leadership positions in all four experiments, which result from our contributions to the instrumentation. A lot of that instrumentation has other application areas. I am involved in grants, as many people here are, that go into other areas. Medical physics is a particularly strong one, both for detectors and, for that matter, accelerators.

My concern is that the ability within the universities to develop that sort of instrumentation, to take on students involved with that instrumentation, and even to train undergraduates with that instrumentation, will be impacted by these sorts of capital cuts. It will not only take the students away from having that contact with cutting-edge technology, which is vital to the training that we should be delivering, but the universities themselves are under pressure to deliver on an impact agenda, which becomes increasingly more difficult if we don't have the in-house capabilities to be developing cutting-edge technologies. It is a double-edged sword in that respect.

The other thing that capital hits, of course, is in STFC's supplementary information. You see how much the subscriptions are, to start off with. Roughly a third, in the case of CERN, was under the capital heading. That gets cut in two, which means that the resource for CERN has to go up by that corresponding £15 million from other places. Fortunately, because of the Wakeham review, it is not coming out of the grants line. You can see that the grants line is being maintained. The capital cuts are also impacting in more indirect ways through that mechanism as well.

Q99 Roger Williams: As I understand it, the capital funding is not only used for building new kit but maintaining the existing kit. What effect are cuts going to have on the existing facilities?

Professor Rawlings: That is, again, part of the worrying trend in terms of making sure that our young people and the whole community have access to world-class facilities. That always requires investment of that kind.

Professor Peacock: The thing is that you can get away with it for a while and you hope that nothing breaks, but it will eventually.

Professor Rawlings: Yes.

Professor Peacock: We can tolerate the situation for a few years.

Professor Seryi: Can I elaborate on this as well in terms of the impact of the capital cuts on facilities? We are certainly grateful that there is sufficient capital to fund the provision of facilities like the ISIS Neutron Source and the Diamond Light Source. This is fantastic. These are facilities that are running and producing great science right now. The lack of capital will impact on the ability to develop next generation facilities that will produce the future generation of science in many areas but also in areas of accelerator science research. So we are trying to develop new methods of how to create new facilities for the future. For this you need various test facilities, which could be small. Those in existence and those new are impacted by a lack of capital. This propagates to impact on trying to attract the best researchers and students as well.

Chair: We are moving on to that in a bit more detail.

Q100 Gavin Barwell: My questions are principally for Professors Allport and Seryi. What do you think the impact of the capital settlement will be on the prospects for the UK's future involvement in post-LHC particle accelerators?

Professor Allport: I think we should both answer because we will be answering from a different perspective. I will be answering from the perspective of an experimental particle physicist who is largely involved in the detector side of things. The first phase in the future within CERN will be the high luminosity operation in the next decade of the LHC. Beyond that there are a number of options, all of which require development of novel technologies.

There are directions which go in terms of the Linear Collider. There are directions which go in terms of the ep collider. There are directions in terms of trying—it looks like a proof of principle, but one can do it—to double the energy of the LHC in the current ring. Then there are a large number of other facilities around the world which tend to concentrate on doing very high statistics experiments and, therefore, require extremely high intensity beams for neutrinos, muon storage rings, e+ or e- for B-factories and so on.

Two things are very important. One is getting to these very high energy gradients, which I am sure you will hear have a range of applications, but the other is developing very high intensity sources. Again, this is not something that just supports our programme in particle physics. It turns out to be very important in a wide range of other sciences to push at that frontier as well. That is an experimenter's perspective. I do not know if you want the accelerator expert's perspective now.

Professor Seryi: I can continue to discuss this project. I believe that there will be a rather serious impact on our ability to contribute to this future generation of projects. A number of them are planned in Europe and the US. From the point of view of accelerator science, indeed, we are trying to develop various methods of how to make future accelerators and colliders better, smaller and less expensive. For this, we need research developments for attracting students and capital funds to make small test facilities. All these are essential components. I really worry about our ability to contribute significantly to these future projects which are aimed at discovery science, like high energy physics and so on, but also I worry about our ability to contribute noticeably to applications of accelerators which are beyond discovery science, which are applications for energy security, nuclear energy security, health, engineering and to developing all the facilities which will be needed everywhere in addition to discovery science.

Q101 Gavin Barwell: In the evidence we have had and, indeed, in the evidence last week, concern was expressed about the shift by the STFC towards focusing research on technology, instrumentation and detector development in-house. Can you say a bit more about what impact you think that will have on R and D work in universities?

Professor Allport: To some extent I am repeating a point I made before, so I apologise. If you go in that direction, what has existed before has been a relationship between the national labs and the universities, which has developed over a very long time, which has got the balance right in terms of what is done within the universities in terms of R and D, in terms of prototyping and in terms of also some significant instrument delivery. Quite a lot of the tracking detectors in the LHC experiments were built in the university sector. On the other hand, you have specialisms in the national labs and it doesn't make sense to employ somebody in the university to do those because those skills for a particular project won't be needed continuously. One example is the design of microelectronic circuits, which is something that is particularly focused on the microelectronics group within the Rutherford Laboratory. There are complementarities there.

As I was saying before, the key thing about having high-tech capabilities and high- tech activities—we are involved in some world-leading instrumentation development in the UK universities—is that it provides a very vibrant training environment for PhD students, particularly those whose focus is going to be more towards technology than, if you like, the more scientific end. We have quite a few students who come through the system using the CASE scheme, which means that they are linked already with a UK company as they come into the department. The sort of training that we can provide for them is critically dependent on us being in world-leading areas of technology and giving those students skills that will make them very competitive, but also from the point of view of the companies that are working with us, they don't want to work with somebody who is second rate. They want to work with somebody who really is first rate.

Professor Rawlings: This is not a peculiarity of particle physics.

Professor Allport: No, it certainly isn't.

Professor Rawlings: If our nuclear physics colleagues were here, they would say the same thing, and also in astronomy. Professor Davies last week mentioned terahertz imaging, which is obviously used in body scanners. That is technology that is often spinning out from radio astronomy. It is extremely important to keep all of this capability in the universities where there are unique skills and where, often, the young people coming through will get the training in those technologies.

Professor Peacock: I would like to add to that briefly and I need to declare an interest here. We have the model right in Edinburgh because the STFC has one of its laboratories there—the UK Astronomy Technology Centre—and it is embedded within the university, so there is no danger that it does things outside of an academic context. It is able to benefit from all the intellectual innovation of a university environment and yet do its own technological work as well. The danger of separating those two is very great, I fear.

Professor Rawlings: I don't think that geographical separation is the key point. As Phil has said, in particle physics there is great collaboration with RAL, which is a long way geographically from Liverpool.

Professor Allport: Yes, and long may it continue. It does require having a strong home in-house capability. Nuclear physics are not represented here, but our colleagues in nuclear physics do a lot of instrumentation development that is very closely linked to nuclear medicine. Many of them hold grants in both nuclear science and in nuclear medicine areas, and they are developing the next generation of PET scanners and things like that. If that were not happening in the universities, I am afraid my own opinion is that it probably would not be happening either at all or certainly not to the level that it is at the moment.

Q102 Gavin Barwell: Can I just press you on this point? In answering questions from the Chairman at the start of the session, you said that relationships had improved, and in relation to taking the difficult prioritisation decisions that have had to be taken, given the financial backdrop, that had worked better this time. Does the academic community support this decision that, in the financial environment we are in, that technology, instrumentation and detector development should just be done in-house by the STFC? Is that something that people have reluctantly accepted or are you saying that you are opposed to that?

Professor Allport: No, I am strongly opposed to that. To go down that path will not only hugely reduce the UK's capability and standing, but it will divorce, in a way that would make us completely anomalous internationally, the instrument builders from the people who use the instrumentation. As somebody who is a detector physicist, without having a foot in

both camps, I can say that it would be almost impossible to be involved at the international level that we are, for example, leading in the upgrades of both the ATLAS and CMS experiments from the UK. They are both university people who are in those leadership positions, and they are in those leadership positions because they are able to integrate closely with what the requirements are and have the detailed knowledge of the technologies to be able to marry the two together.

If you try a model that says you draw up a specification and somebody else goes and builds it, my specification is that a detector has to be zero mass; it has to have no noise; it has to have infinite signal; it has to generate no power, etcetera. Of course, that is a useless starting point for any discussion. Any detector that you develop is a compromise between what the key parameters are and what is technologically possible, and that can only happen if you have a foot in both camps.

Professor Peacock: In astronomy, I cannot see why one would want to have that kind of concentration. The way to do this is to exploit the expertise that exists in universities by helping them, so individual university groups will have nuggets of expertise that cannot develop on their own. You need a central organisation that can pull them together and have traffic going in both directions. We have that at the moment, and I do not think that we necessarily want to break it.

Professor Rawlings: It is a collaborative thing that actually works. I don't think anyone should be dogmatic about where technology is in place A and science is in place B. The reality is that, to do the science we need to do, you need innovative technologies and so you do need to mix and match these things.

Professor Kennicutt: I think your question really highlights the fact that one of the key challenges of managing this council is its structure because, on the one hand, it is trying to support and promote its own laboratories and, at the same time, optimise the output of the universities as well. It would be a difficult job for anyone.

Q103 Gavin Barwell: It is a difficult balance to get right.

Professor Kennicutt: It is one of the things you look for in the next CEO.

Q104 Gavin Barwell: You have made the point. You have put your views on record very clearly. I have one final question specifically on particle physics. In evidence to this Committee last week, the President of the Institute of Physics said that she felt that within the field of particle physics the STFC was concentrating all its eggs in one basket and that more of the money should go outside of the CERN project. Is that something that you would agree with?

Professor Allport: It should even go outside the projects which are funded within CERN. If you look at some of the evidence that has been submitted, you will see that, with the prioritisation process, you almost inevitably end up with a correlation of high cost, high priority and low cost, low priority. The prioritisation process in the way that it has been executed does need to be a little bit more nuanced, because we now see in the submissions that there is a clear budget line.

If one were to take a budget and say, "How do I best fit a programme into it?", then one could do the high priority, high cost, but also try and get the Alpha 2s and 3s—Alpha 2 or Alpha 3 means that this is excellent international science—and try and get those low cost projects into the envelope so that you have a wider portfolio. This requires a different style of managing the science within each science area. It is more subtle than taking a priority listing and then saying, "Everything less than Alpha 3 gets cut." There is room, even within a constrained budget, for trying to broaden the programme, but it requires some different methodology to achieve that.

Q105 Stephen Metcalfe: I would like to return, if I may, to the proposal to withdraw from ground-based northern Hemisphere facilities. How important is it to have access to those facilities for our UK researchers and astronomers?

Professor Kennicutt: I guess that is mine. This was one of the issues, front and centre, in the Ground-based Facilities Review in 2009, which advised the STFC. The decision to rank Gemini low, knowing that that would probably lead to other problems, was a difficult one, but we made it on the basis of cost-effectiveness. The impact, as background, was to remove a major northern Hemisphere 8 metre telescope. In that report we argued quite strongly that to mitigate, should we withdraw from Gemini, that would create an even stronger need for the remaining facilities in the north.

For example, the William Herschel Telescope, out of the 25 facilities, I believe it was, that we prioritised, was ranked fourth in that review. So it is important. It not only offers access to the 40% of the sky you can't see in the south but many of the instruments are unique on La Palma and Hawaii. There are many complementary capabilities, such as the white field imagers, spectrometers and so on, that can very effectively do science as effectively as you could with a much larger telescope that you clearly wouldn't want to spend the time on. The cost is low. For the three telescopes on La Palma—I don't have the exact figures—it is about £1 million current spend compared to the £5 million to £6 million that you save from Gemini. It is a very important capability at a relatively low cost that we believe so strongly should be maintained.

Q106 Stephen Metcalfe: So you are saying that the cost of the facilities at La Palma is around £1 million. We were told it was £2 million to £3 million last week, which we thought was very reasonable. If it is only £1 million, why are we even considering not carrying on with that facility?

Professor Kennicutt: First of all, I also read Roger Davies's testimony and the £2 million to £3 million. I only read the transcript that was released yesterday so I was not able to touch base. I believe that he was

including some capital cost of instrumentation to enhance the facilities. The number I gave was just the maintenance cost. It may have included some of the Hawaii facility time as well.

Professor Peacock: The specific number on Hawaii I can certainly give you. Exactly £3 million are the running costs for the two telescopes: the James Clerk Maxwell Telescope and the UK Infrared Telescope on Hawaii. That is also coming down because we are doing partnership deals on the UK Infrared Telescope with the Koreans. So there is the scope to keep these things going with economies. The staff of these observatories should be congratulated on what a good job they have done in that regard of keeping the science flowing for less money. We can sell off a bit of it. But the reason they have to stay is that it lets us get value out of the big things. If we have some unique piece of instrumentation on, say, the Herschel Telescope or UKIRT, we have access to a project and we can then go to ESO and say, "We want to use the ESO telescopes to follow this up." If nobody else in Europe can do it, it gets us better value for our ESO subscription. If you take away these small facilities, we have nothing special to bring to the table.

Q107 Stephen Metcalfe: If you had to prioritise one of those smaller northern Hemisphere ground-based facilities, which one would you prioritise?

Professor Kennicutt: That is a difficult question. In the Ground-based Review we attempted to split hairs, but in hindsight the problem with that argument is that there are fixed infrastructure costs on these remote mountain top facilities. So, even though I don't know what the book value of the Liverpool Telescope is now, if you were to book—let's just pull a number out—£0.25 million of savings, you actually wouldn't save nearly that amount because you would still have the fixed costs. On the one hand, the cost-effectiveness of these is really in the total. If you want to close something, of course, the argument works the other way. You then fall on a slippery slope where soon you have to close an entire mountain-top facility to realise savings. That is what we are trying to avoid.

Professor Peacock: The answer is that, if pressed to choose between them, we would say we do not accept that as a valid question. We would choose to squeeze the costs further, to seek further partnership deals, because both of these small things have important roles. A few million pounds a year is a lot of money, but in the context of the STFC's budget it is not.

Professor Rawlings: I think there might be a bit of confusion here. There are northern Hemisphere optical telescopes. We have heard about La Palma and UKIRT, which is a near infrared, effectively, optical telescope in Hawaii. The actual cost of running UKIRT in Hawaii is extremely low, much lower than the number that you might have inferred from what John said, because it is run alongside a sub-millimetre telescope, the James Clerk Maxwell Telescope. There are also the northern radio telescopes. e-MERLIN, in our own country, is a world-leading facility.

One has to be a little bit careful about whether you are talking about northern observatories or northern optical observatories. The argument for the northern optical observatories is their value for money. Due to the STFC's management of what is going on but also the incredible management of those facilities by the people who have been asked to make major cuts, they just are spectacularly good value for money. I speak as someone who has just been out to use the William Hershel Telescope to observe objects that were detected by the Herschel Space Observatory. That is an example of where we are getting this extra international leadership.

Professor Kennicutt: Those low costs that I cited were not the costs a few years ago. They have been negotiated down creatively, to the credit of both the STFC and the managers of those observatories.

Professor Bode: So it is a combination of driving the costs down and bringing in additional partners as well. To give some surety on bringing in those additional partners, you still need to have some baseline funding from the STFC into the future because those additional partners want to see that the whole show is going to be on the road while they are funding part of it.

The other thing I should just add to what Steve was saying is that those northern Hemisphere radio observatories work in a complementary way to the northern Hemisphere Optical Infrared observatories. There is, obviously, e-MERLIN. There is a project that the Dutch lead called LOFAR, which is another radio observatory working on a new part of the spectrum, effectively. The UK has a significant interest in that. There is a new LOFAR station in the UK, for example. For those reasons and all the scientific reasons that have been pointed out in the submissions and the evidence by Professor Davies and Professor Bell Burnell last week, the northern Hemisphere access is vital to the health of the community into the future.

Q108 Stephen Metcalfe: When you talk about additional partners, do you mean industry?

Professor Bode: No, not necessarily. I mean international partners, partnerships through EU grants that have been given to individuals and institutions that buy out time on telescopes, and UKIRT is an example that the Koreans bought into.

Q109 Stephen Metcalfe: But could industry be an alternative source for this funding?

Professor Rawlings: That depends on the project. In the northern Hemisphere optical observatories—correct me if I am wrong—they are probably an unlikely partner in that sort of endeavour. For example, in radio astronomy, which I work in, we are very actively engaging with industry to try and develop facilities for the future. Again, it is a slightly complicated picture.

Professor Bode: There is a possibility of a commercial partnership to do with something we will probably talk about later on, which is the National Schools Observatory in terms of time on the Liverpool Telescope, but that would be rather unusual in this context.

Professor Kennicutt: There is one other specific example. This issue of access to northern Hemisphere

facilities and small telescope facilities is recognised at the European level. There is a European funded network called Opticon, which is engaging in a study of how the major European players, mainly ESO members, can collaborate in operation and time allocation on these. They are issuing a series of reports. Over the long term, the answer is probably to collaborate. That not only will spread the cost over a larger base but will tap European Research Council money to help defray the cost.

Professor Rawlings: That is certainly the plan for the European Extremely Large Optical Telescope as well. That is certainly something for the future.

Q110 Stephen Metcalfe: If we do not continue to play an active role in these facilities, do we have access to the observations, the data and the research that come out of them? Even though we are not directing it, do we have access to it?

Professor Peacock: Eventually, yes. It is almost universal now that observatories—this idea is driven by NASA as much as anything and the Hubble Space Telescope—have a duty to take the data and put it into the public domain. If you had any spare time, you could do astronomy with data from the William Herschel Telescope, but you don't get it immediately. There is normally a cooling-off period of one to two years. Of course, that is critical. If your competitors have that head start, you won't catch up.

Q111 David Morris: Gentlemen, can the National Schools Observatory continue to operate without continued funding by the STFC of the Liverpool Telescope? Professor Mason suggested to us that there are "other partnerships and arrangements that one could make." What could these be?

Professor Bode: I guess that is directed at me. I have a vested interest here. The NSO is intimately tied up with the operation of the LT. Right from the start, the LT was a science- driven project to provide a robotic telescope that could react very rapidly to things that changed in the sky and then observe things systematically for as long as is scientifically important. We realised right at the start of that project that we could engage schools in this because they could upload their observations into the same queue that professional astronomers' observations are loaded into. Then we could distribute those things to schools with the appropriate software to analyse them. There is a symbiotic relationship between the LT and the NSO. They have grown up together and they are intimately related. The NSO relies on the functionality of the LT. Not only that but the NSO is there not just to train or encourage the next generation of astronomers. It is much broader than that. It is there to enthuse young people about the study of STEM subjects.

As we heard last week from those extremely eloquent young people who gave evidence to the Committee, one thing that they thought was very important was to see some linkage between what they were doing and research, that they wanted to be using cutting-edge instruments. With the LT, that is exactly what they are doing. Could the NSO programme be moved on to another telescope? Within the STFC's area, there is not another robotic, professional research telescope on an excellent site to which that could be moved. So could we find another telescope around? There are telescopes that we actually built in Liverpool. For example, the Faulkes Telescopes have a schools programme, but they are not even UK-owned. We would then have to buy out the time on other telescopes somewhere and integrate the NSO again into those telescopes. The most cost-effective way of doing this, to my mind, is to have the NSO with the LT and continue in that way. That depends on the future funding of the LT, of course.

Q112 David Morris: What level of funding would be required to ensure the continuation of the telescope at Liverpool?

Professor Bode: In relation to the Liverpool Telescope at the moment, our operational costs are partly from the university, but the majority of the costs come from the STFC. The costs at the moment from STFC are around £0.5 million a year. We have a planned programme of voluntary redundancies of some of the staff and efficiency savings that bring our costs down. We have a very active programme, like the other telescopes in the northern Hemisphere, of seeking additional partners. Our aim is to halve the STFC's contribution over the next couple of years to about £250,000 a year. We think that is a realistic target for the operation of the LT.

As far as the NSO is concerned, the all-up cost of the NSO, if you include the overheads, heating, lighting and all those sorts of things, is £150,000 a year, roughly. That does not include the 5% telescope time that the university gives to that project. That is to keep the show on the road at that level. At the moment, that is underwritten by the university, but, obviously, times are tough for universities as much as for anybody else and the university has to prioritise that within its own budgets into the future. We would like to be reaching a much larger community. We reach something like 2,000 schools in the UK at the moment, predominantly secondary schools, which is a goodly fraction of all the secondary schools.

We have projects there that range, potentially, from languages and geography, through the sciences, etcetera, and we could extend it to primaries, too. We want to increase the number of schools and we want to increase the penetration that we have into schools. As we saw last week, if there is one thing that turns kids on, it is the science that is represented around this table.

Q113 Chair: Do you see it as part of the role of the STFC to support education programmes like that, or should they just spend resources on funding excellent research?

Professor Bode: The STFC's chief executive was quite right when he said that the STFC's primary remit is to support research. However, they also support outreach. I think the budget of the STFC for outreach—Science in Society, as it is now—is about £1.6 million a year. That has been reasonably

protected, which is very good. About £400,000 of that goes into a central pot in the research councils. What you are then left with is a relatively small level of resource. The STFC's Science in Society programme does a lot with that £1.2 million, but they have to prioritise like the rest of STFC. What they prioritise are new projects. The NSO has benefited from that new project funding in the past and, hopefully, will in the future, but, as far as something that will maintain the operation is concerned, at the moment that is not a priority of STFC's Science in Society programme, as far as I understand it. Maybe that should change or maybe there are other ways of doing this.

One possibility, as I mentioned in the evidence, was more of a dialogue in the first instance between the STFC and the Department for Education, for example. We seem to fall between the stools. It would be very good for more of that type of partnership to be struck up. I saw in the Delivery Plan in the Science in Society section that they want to develop more partnerships. I may have missed it, but I didn't see this as being one of them and maybe it should be.

Q114 Chair: Gentleman, thank you very much for some extremely useful evidence.

Examination of Witnesses

Witnesses: **Professor Keith Mason**, Chief Executive, Science and Technology Facilities Council (STFC), and **Professor Sir Adrian Smith**, Director General, Knowledge and Innovation, Department for Business, Innovation and Skills, gave evidence.

Q115 Chair: Good morning, gentlemen. I do not have to rehearse with either of you the direction of this inquiry. What I would like to do to start with, Professor Mason, is to pick up where we left off with the immediately previous panel. Do you still see the future of the NSO as an "educational issue", or does some responsibility lie with the STFC?
Professor Mason: First of all, I have to say the NSO is a really fantastic initiative, which I personally have supported since its inception. We do support the use of the Liverpool Telescope for research and will continue to do so for the next few years. In terms of the observatory use for education, we have schemes for public outreach for which things like the NSO can bid, they have bid and we have supported them in the past. We will continue to be open to that but, of course, that has to be done in competition with other bids.
Chair: Sure.
Professor Mason: We are primarily constituted to be a research-supporting organisation. The main responsibility for mainstream educational use has to lie with the appropriate authorities.

Q116 Chair: Have you had any discussions with the Department for Education about this?
Professor Mason: No, I have not, because the Liverpool Telescope and the NSO is not owned or operated by the STFC. It is the responsibility of Liverpool John Moores University. However, were Liverpool John Moores to ask me or the STFC to support a dialogue with the Department for Education, I would be more than happy to do so.

Q117 Chair: Sir Adrian, where do you see the boundary lying? Is it the responsibility of the Department for Education or the STFC? We are all agreed in this room about the importance of exciting young people about science. Where do you see the boundary line?
Sir Adrian Smith: In general terms, within BIS and our Science in Society funding, and in our encouragement of delivery plans with the research councils, we, obviously, have an interest in outreach and stimulating interest in the young, but that must be done appropriately within the terms of reference of individual bodies. The responsibility and ownership of this particular entity really lies with Liverpool John Moores University. As Keith Mason has said, if they were to make an approach for help, assistance or backing in terms of approaches to DfE, we would be more than happy to join in, but it is not the primary responsibility either of BIS or the STFC.

Q118 Chair: So it is not BIS and it's not the STFC. The Department for Education hasn't woken up to pick up the cudgels and run with it yet. Have you discussed it with your colleagues in the Department for Education?
Sir Adrian Smith: Down to the level of specific instances like this one, no, but we do have regular dialogues. Very recently, we had a high level dialogue with DfE on issues of mutual interest, including STEM education. A meeting is planned that will have two Ministers—Nick Gibb and David Willetts—involved with a group of people with primary front end interests actively in STEM education. There are plenty of fora to discuss the issues. As I say, it is not the remit and responsibility either of BIS or the STFC to run with a particular entity.

Q119 Chair: It may not be your responsibility, but it is part of your responsibility to help improve public understanding and engagement with science.
Sir Adrian Smith: Yes.

Q120 Chair: It is clear from the evidence we have heard, especially from the young people, that this is an effective tool. Therefore, isn't it part of your responsibility to recognise that there is, as one witness said this morning, the possibility of this falling between two stools and doing something about it?
Sir Adrian Smith: The primary responsibility is with those with the direct ownership to make approaches to us for help in conducting conversations. It is not our primary responsibility. The world of STEM out

there is huge. It is not for us to get involved at that micro level in terms of total responsibilities. As Keith said very plainly, if they were to make an approach to him it would be treated with interest.

Q121 Graham Stringer: Last week and this week we have heard fairly compelling evidence, both on scientific and financial grounds, that it would be possible to keep access to the northern telescopes for our astronomers. Do you accept that evidence? You must have read our evidence session last week.
Professor Mason: We all agree that access to northern Hemisphere telescopes is not only good science but good value for money. But we are in a tight funding environment, and in that environment we are trying to find a way of maintaining access to the northern Hemisphere. One has to recognise that even an amount of £1 million is a significant sum. It has to be found from somewhere and traded off against, for example, funding postdocs in universities. It is very tricky.

Q122 Graham Stringer: It is a pure administration cost.
Professor Mason: Indeed.

Q123 Graham Stringer: We will come to postdocs later. There are other areas where relatively small sums can come from.
Professor Mason: Believe me, we are squeezing all of those areas in order to get the maximum amount of science out of them. The point is that it is a question of priorities and prioritisation. We accept that access to the northern Hemisphere is important and we are actively seeking ways of providing that access. Indeed, to be clear, we are maintaining support for the Hawaii Telescopes for more years than we previously believed we were able to do for that very reason, and we are actively seeking to provide some access to telescopes on La Palma. Those are negotiations in progress and they are not yet concluded, so it cannot be guaranteed. What we are doing, according to our long-term strategy, which I outlined when I saw you in January, is withdrawing from ownership of our telescopes on La Palma, but that does not mean that we cannot negotiate some access to those telescopes.

Q124 Graham Stringer: That sounds good. You, effectively, agree with what Professor Davies and Professor Bell Burnell said to us last week, that access to these telescopes is important for the future of astronomy in this country, and you are trying to achieve that.
Professor Mason: Yes. Let me state it more broadly. Astronomy is important to this country and access to appropriate facilities goes part and parcel with that prominence. We have to operate within a constrained funding environment, as does every country, particularly in these times, and we have to prioritise. The clear advice that we have been given is that the top priority has to be world-class facilities and, particularly, the world-leading facilities that are provided through ESO, but that does not mean that we won't seek to provide as much access as we can to supporting facilities. I wish we could do more. I wish we did not have to withdraw at all from La Palma. In an ideal world we would not, but it is a constrained environment and we have to make hard choices.

Q125 Graham Stringer: The real weight of the evidence we heard last week and again this morning was that, if you can't look at all the sky and you are only looking at what you can see from the southern Hemisphere, it would be more difficult to attract the best astronomers from around the world coming to do astronomy here. You are actually detracting from first-class science if you can't look at all the sky. Do you accept that?
Professor Mason: It would be more detrimental not to have access to the Extremely Large Telescope, for example, or the ALMA Telescopes, which are in the south, because they are absolutely cutting-edge, world-leading facilities. This is as much a scientific debate as a political debate, because a large fraction of astronomy research doesn't care which hemisphere it's in because it requires samples of a particular sort. There is a subset of astronomy, however, that does require access to particular objects in the north. Those are important, and we are seeking, as best we can, to provide the facilities to allow that sort of science to continue.
To come to the central part of your point, if we want to retain the excitement and encourage more people to come into astronomy, we have to be supporting and be involved in absolutely cutting-edge facilities like the ELT, ALMA, the Square Kilometre Array in the future and the VLT telescopes at ESA. They all happen to be in the southern Hemisphere.
The other factor in this is that astronomy facilities, as we become more sophisticated and want to push to more and better science, are becoming more and more expensive to the point where no nation will be able to support equal capability in both hemispheres. We have to make a choice.

Q126 Chair: The research councils found 20 times that sum to cope with the overrun on the shared services facility. We are talking about very small sums of money. Surely, that can be found.
Professor Mason: But that is what we are doing.

Q127 Chair: Do you think that £2 million to £3 million can be found?
Professor Mason: Yes, we are actively looking at how to do that, but it is a trade-off against other things and always has to be. As to "other things", it is easy to say that we have to find it in administration costs. Our baseline administration costs are being ramped down, in any case, so it is very hard to see how you can squeeze any more out of what is already a challenging situation. The unfortunate truth is that that £2 million to £3 million would have to come out of other areas that are scientifically productive. Therefore, we have to look to prioritise and we seek advice from our communities in doing that.

Q128 Stephen Mosley: I was interested on that last point. If you look at the figures, you are looking at about a £15 million reduction over the next couple of

years. £9 million of that is already accounted for because it is the residual costs of joining the ESO, which expires in 2012. So you have got £9 million straightaway. The other £6 million is, effectively, Gemini, etcetera. From what you have said and from the numbers, it looks like you are not reducing your baseline costs at all.

Professor Mason: I am confused. Which baseline costs?

Stephen Mosley: The administration costs, etcetera, of running the STFC.

Professor Mason: No. First of all, in the current spending review, the admin budget is ring-fenced in our allocation, so we cannot vire between them in any case. The admin budget that we have will suffer a reduction of something like 10% over four years, which we are meeting through efficiency gains. Admin is a red herring, in a sense, but what I can say to you is that we are looking for every possible way of getting more for less so that we can do more. One of these "mores" is access to the northern Hemisphere telescopes.

In the case of the Hawaii telescopes, we have found the savings to be able to continue operations at the JCMT for another two years. As previous witnesses have highlighted, we have substantially reduced the cost of operating our UKIRT telescope by finding efficiency savings so that we can continue to operate that. We are making very positive efforts in this regard. We are fully behind the community in saying, "Yes, this is important", and we are trying our best to fulfil their requirements.

Q129 Graham Stringer: Obviously, there are all these priorities and we are in a cash limited situation. You told us previously a number of things, one of which was that this was a strategic scientific decision to withdraw from the northern Hemisphere. You said we were over-investing in astronomy because of the initial costs in the ESO. What I am really trying to get to is this: we have heard that there are very strong scientific reasons for staying in the Northern Hemisphere, and I want to know whether it is just cash, which it seems to me that it is, or whether there really is a scientific strategy behind your policy.

Professor Mason: Maybe it would be helpful if I were to clarify the point about the strategy, which was not a scientific strategy but a financial strategy. Perhaps it would be helpful if I quoted to you from the papers that were looked at in 2001, on 5 December, from the PPARC Council meeting, concerning the accession to ESO. I will just read a little section here. It says: "Note that the above programme represents the first phase in re-shaping PPARC's investment in ground-based astronomy facilities over the next decade. The long-term strategy will see PPARC withdraw from the AAT, JCMT, UKIRT and the ING by the end of the decade." So that was the financial strategy that PPARC adopted in 2001 as part of the arrangements for the affordability of entry into ESO.

In the meantime we have rowed back from that position as much as possible because it is scientifically desirable. As I have said, we have not withdrawn from JCMT and UKIRT by 2011, i.e. this year, which is what the original strategy foresaw, and we are making efforts to retain access to the telescopes on La Palma. We have withdrawn from the AAT, and that was completed in 2009. That was a financial strategy. It was one of affordability. Within the financial constraints we are trying to optimise the scientific strategy that we are pursuing.

Q130 Graham Stringer: I have two questions. One is that the administration is ring-fenced. Is that ring-fencing a Government ring fence or is it your own?

Professor Mason: It is a Government ring fence.

Q131 Graham Stringer: I think you have said that you wanted to find this money to keep access to the northern telescopes. If you are unable to do that, do you believe that there is any scope for UK industry providing that funding?

Professor Mason: I think that would be a relatively hard sell, unless one was able to do so on the back of generating novel instrumentation, which they would be directly interested in. UK industry is more interested in the cutting-edge developments that would flow, for example, from the Square Kilometre Array or the Extremely Large Telescope. Of course, we are engaged with them in promoting that. That is to the benefit of everybody.

Q132 Stephen Mosley: You have pretty much or partially answered the question I was going to ask, which is about this over-investment that we have had over the past decade. I know when we spoke to you in January that you mentioned it, but, when we heard from Professor Dame Jocelyn Bell Burnell last week, she seemed to imply that a lot of these financial gains had been made previously with the closure of other things. You did mention this document from 5 December 2001. Do you think you could submit that to the Committee so that we could see the evidence?

Professor Mason: I would be happy to do so. It contains a lot more detail about the discussions and the strategy. It was a very difficult discussion—I remember it—at the time about whether or not to join ESO, because we recognised that in doing that we would be giving up at that point national sovereign facilities. It was a very heated discussion with the community. It would be very interesting for you to read the detail of that, but the resolution and the right answer was arrived at because we are now pursuing a strategy of access to absolutely world-leading facilities in order to keep our scientific communities competitive, to attract the right people and to inspire.

Q133 Stephen Mosley: There has been an impression that you have been making the astronomy community pay twice for ESO membership in terms of gradually closing down facilities over the past 10 years, and then turning round now and saying, "Look, we made this commitment 10 years ago. We've got to close these things down." Can you categorically say that you are not making the community pay twice at all?

Professor Mason: The point I was trying to make was that we are doing better than the original strategy, which would have had more draconian cuts by now than we have implemented.

Q134 Stephen Mosley: Starting to look forward, when you spoke to us in January you said that you were hopeful that we would find a way of building the European Extremely Large Telescope. "Hopeful" implies that there might be some doubt. Is there any doubt about the UK continuing to play a leading role in the development of the telescope?

Professor Mason: No. The doubt, such as it is, and I don't want to overplay this, is that we have still to see a firm plan from the European Southern Observatory as to what the telescope is going to be, how much it is going to cost, etcetera. They are working on that with a proposal that will come forward later this year. Provided that meets our objectives and is satisfactory, and I have no expectation that it won't be, then we do have provision in our forward planning to be able to support UK participation in the ELT. In fact, it is one of our very highest priorities. It is very welcome. It is a very exciting project and one that helps to keep this subject and UK research in general at the forefront of the world.

Q135 Gavin Barwell: Professor Mason, I am not sure if you were here for the section in the previous inquiry when we dealt with this issue about the decision to focus research on technology, instrumentation and detector development in-house. If you were, you will have heard Professor Allport say that he thought that decision was completely anomalous and that he was strongly opposed to it. The Institute of Physics, in their submission, said to us that the decision was based on a misconception of how cutting-edge science and its associated innovative technology are related. Could you explain, from your point of view, the rationale for that decision and how you respond to those comments?

Professor Mason: If we had made that decision, I would not be for it. The fact is that we haven't made such a decision and I am very grateful for another opportunity to clarify our position on this. We have tried to explain to the community that they don't have a lot to worry about in this regard, but let me try and articulate why.

Let me read the sentence in the Delivery Plan that causes all the angst and the problems: "We will focus the capabilities of STFC's in-house researchers, especially in astronomy, particle physics and nuclear physics, on technology, instrumentation and detector development, allowing university scientists to concentrate on research."

What we are trying to say there is, essentially, a re-statement of our existing position and the existing mission of our national laboratories, which is that they are there to support the scientific communities, and in particular in these capital intensive areas of building large detectors—not doing the detector R and D but building large instrumentation. What we were trying to capture there was not so much that we were going to prevent the universities from doing technology development, but we were going to encourage our in-house researchers not to compete with the universities in terms of scientific research and to concentrate on their core mission, which is to support the university communities in their endeavours.

The reason that this, to some eyes, apparently innocuous statement has caused a good deal of anxiety is the overall context for the research councils, where we are facing, as you know, severe restrictions on the capital budgets. As RCUK, we are adopting a clear policy, which is, I think, a very sensible policy, of not duplicating large technical capabilities unnecessarily. We are encouraging universities to share facilities, unless that is justified in another way such as putting in bespoke capabilities in a particular place, and we are also encouraging them to use our national laboratories, which is, after all, what they are there for, to support their research efforts.

There is a wider RCUK context in which we have a strategy for dealing with the very unpleasant restrictions on capital that there are, but, within the STFC context, all we are trying to do here is to re-state and re-clarify what has always been the case. The national laboratories are there to provide the technical support for universities, particularly in building large bits of kit. I would re-emphasise once and for all that we are not intending, nor would it be sensible, to restrict the university community from doing technical R and D and from doing blue-skies research of a technical kind. That would just be totally counter-productive. I hope I can lay that to rest once and for all.

Q136 Gavin Barwell: That was very helpful. What do you think it says about the relationship between the council and its academic community that what you clearly regard as a complete misunderstanding has occurred and persisted? The document you are talking about was published at the end of last year.

Professor Mason: Yes.

Q137 Gavin Barwell: It has been running for a number of months, yet when we called for evidence to this inquiry, clearly, that misunderstanding, as you regard it, still persists. What does that say about the relationship?

Professor Mason: I have every sympathy with our communities that have gone through a very difficult period. We have had to adjust to a financial climate which is not as benign as it was earlier in the decade. It might sound like a very small shift to say that we are going from a constant volume to constant cash, but it has a huge impact, as we have seen, particularly in a research council like the STFC, where we have such a large fraction of our programme tied up in long-term commitments, which are fixed. In being required to change tack very rapidly, as we were required to do, clearly the squeeze on the flexible parts of the programme is more marked. I understand the fact that the community is very sensitive to any change, and, indeed, suspicious of Government policy and research council policy in many areas, but what we have done over the last few years, while it has been painful, has borne fruit in this 2010 spending review.

As many people have commented, it is much better than we feared it might be, and the reason that it is much better than we feared it might be is twofold. First, we have over the years, since the inception of the STFC, highlighted and addressed the structural

problems. The fact that, this time, facilities and international subscriptions were dealt with in a separate ring fence and, essentially, top-sliced from the overall research programme, means that we have a much more sustainable way of dealing with these things. The argument that we have been making for years is now accepted—that these are national investments and not something against which there should be tension in one part of the programme.

We have been through a very difficult period. However, we now have at least stability at a level that is below optimum, in my view, but at least a level of stability where we can build for the future. That is what I am anxious to set us going on, which is making the case for additional investment to restore what is not only a very healthy but an essential part of the overall research programme of the UK.

To risk going on longer than perhaps you would like, the case that we have been making, particularly in terms of particle physics and astronomy, is that it is not just of intellectual curiosity, but it is vital to the future health and prosperity of this nation to have people thinking at the cutting edge, thinking outside the box and developing skills and technology that have huge utility across the rest of society and the rest of the activities in which this nation is engaged.

Q138 Gavin Barwell: I have one more question for you, Professor Mason, and then I have one question for Sir Adrian. In the STFC's submission to our inquiry, you state that "...the reduced capital available will potentially have impacts on programmes such as accelerator research and development." Could you provide a bit more detail? For example, do the ALICE and EMMA projects at Daresbury and the proposed accelerator research centre have a future, in your view?

Professor Mason: This is something we are debating at this time. I believe I said to you in January that we have done relatively well as a research council in terms of capital because of the recognition that a lot of the capital goes through our international subscriptions, supports our facilities and should be top-sliced. The main impact for us is the ability to start new initiatives and to develop those in a timely manner. This is an argument that my research council colleagues and I are making strenuously. You cannot sustain a healthy programme unless you invest in new capabilities.

In the case of the ALICE instrument, that is a microcosm of various debates that are happening. We have to make a decision as to whether the best science and the best programming comes from continuing to operate that or, perhaps, diverting those resources into starting new activities that can build for the future. That is a debate that the relevant people are conducting as we speak.

Q139 Gavin Barwell: What is the time scale for a decision on that one?

Professor Mason: I am hopeful that we will get clarity on the direction forward within the next couple of months.

Q140 Gavin Barwell: Sir Adrian, as you know, the UK has already withdrawn from a number of international projects such as the International Linear Collider. Are you concerned about the UK's reputation as a reliable international partner when it comes to these large collaborative projects?

Sir Adrian Smith: As has been said many times, and it is rather tedious to keep repeating it, we all understand the background fiscal position. Most of us would take the view that within those fiscal constraints, the Government sent strong signals that it did recognise the importance of science and research by the relative protection of cash. Capital is difficult, of course. We did have a considerable round of negotiations with partners in CERN and elsewhere in the context of those fiscal constraints on things like subscriptions. In general terms, broadly, there is no mood out there that the UK is an unreliable partner. There will be specific projects that one might have wanted to be involved in that cannot be done. That is all part of the prioritisation project. But any kind of exaggeration that the UK is suddenly not a major international player or that our reputation is not respected is nonsense.

Q141 Graham Stringer: Professor Mason, I would like to take you back to Gavin's question about the misunderstanding that you say there is between the universities and the research community and your plans for where work on detectors would be. I caricature what you are saying, but you are saying that the research community is anxious because of the cuts and, therefore, they have misunderstood them. Is there not a huge responsibility on you to make sure that people do understand those cuts? The submission from the university of Manchester quite clearly understood that what you were doing was to take the basic research out of their laboratories and other similar universities.

Professor Mason: I agree. I would characterise it more that in the current financial climate—and I would do exactly the same if I were them—they want absolute clarity about what we meant. They don't want to find that they have misunderstood or whatever. I am happy to offer that absolute clarity. Hopefully, in this public session today we can lay that one to rest. Why would we do such a thing? It would just be totally counter-productive.

Q142 Graham Stringer: That is why they were worried. What you are saying is very helpful and I am sure it will help those people in the university departments, but should you really leave it to a public session of the Science and Technology Committee of the House of Commons to communicate in that way? Shouldn't you be communicating directly and clarifying?

Professor Mason: We have done so. My director of science programmes attended, for example, meetings of the IOP and of the RAS in which he made this absolutely crystal clear. Frankly, I am a little surprised that it is still an issue, but I recognise, as I have said previously, that if I were the university community, I would want absolute clarity, too. I am very happy to keep re-stating the position. There is no sub-text here.

There is no subterfuge. There is no hidden plan at all. This is exactly as it seems, which is just re-stating where the national laboratories fit into the overall landscape of scientific research in the UK.

Q143 Graham Stringer: I would like to move on to another piece of written evidence that we have had from Professor Stephen Hawking, who said: "It has been said that not all research and development comes from our Universities, but that all our researchers do." That is his direct quote. Are you concerned about the longer term consequences of under-investment in postgraduate and postdoctoral researchers?

Professor Mason: Yes. Put it this way. There is always the question going round of how many researchers you need. A priori, the Treasury asks us that all the time, "How many astronomers do you need? How many particle physicists do you need to be effective?" There is a very simple answer to that, which is that particle physics, astronomy, nuclear physics and a number of other areas, but those specifically, contribute hugely to our economic health, our development as a society and in many other ways. We are certainly not at the point of diminishing returns.

Money for research is very much an investment and not a cost. It is certainly not a luxury. If we invest more, we get more return. A survey recently has been published of the destinations of research students over the last nine years, and, given the huge demand particularly for our graduates, out of that entire cadre, only, maybe, 1% were unemployed. Most were earning more than the national average for the professional classes, even though they are at the early stages of their careers. There is both anecdotal and quantitative evidence that these graduates are in huge demand. We need more of them. If we had more resources, we could generate more of them. We are not, as I say, anywhere near the point of diminishing returns. Yes, I am concerned, in the sense that we need to get the case across that we need to invest in talent. That is what is going to keep this country healthy in the future and we are a prime source of that talent.

Q144 Graham Stringer: I think everybody would agree with that, but the written evidence the Committee has received indicates concerns that the number of research grants that you are giving out to postdocs and postgraduates is at an all-time low. Is that the case?

Professor Mason: In certain areas it probably is the case. In terms of studentships, we have sought to protect the number of students that we support. It has gone down, but it has gone down less than the rest of our programme. In terms of the number of postdoctoral researchers, yes, it has declined simply because of the constraints that I outlined earlier, and it is magnified by the fact that we have such a large fraction of long-term commitments that are beyond our immediate control in the short term. So the postdoc numbers are part of this little amount of flexibility we have and, clearly, they suffer much more proportionally.

This is not a situation with which I am comfortable. We need to find a way of restoring that capability, because, as I have said, it does affect the flow-through of talent into the rest of the economy, not to mention the ability to stay at the cutting edge of research.

The good news is that within the SR 2010 settlement we at least have stability, and even the ability to grow slowly, provided inflation is kept under control. That is another factor that we have to bear in mind. I, for one, will certainly be promoting the case, as the economy improves, that we need to see this as an excellent place to make additional investment.

Q145 Graham Stringer: Do you think you could provide us with the equivalent figures for each of the last seven or eight years on resource spending on grants compared with the last financial year? I think that would be interesting to look at.

Professor Mason: I can provide you with those numbers.

Q146 Graham Stringer: Finally, the capital spending on grants to higher education institutions will be about a third of the level in 2014–15 as it is in 2010–11. Can you explain why those grants are falling so precipitately?

Professor Mason: Yes, and that is a worry. The good news, if there is any, is that the fraction of the total resource—"resource" is the wrong word because we now use that in a different context—or in terms of the total amount of money going to universities in the form of grants, capital is a very tiny fraction of that total. In the previous financial year, we spent of the order of £4 million only on capital and that will reduce to a bit more than £1 million.

Q147 Graham Stringer: It is a small sum of money in absolute terms. It is falling quite dramatically. Can you tell us what kind of areas will suffer because of that large fall?

Professor Mason: I am sorry?

Graham Stringer: What projects will not go ahead because of that cut?

Professor Mason: This category of capital is mostly concerned with small equipment, computers and supportive equipment for general research. Again, the good news is that, with regard to the major capital commitments that we have for our international subscriptions, some of that comes back to the UK. For example, in the case of the ELT work, the capital for that is provided through the ESO. We pay ESO some capital and that comes back to the UK to cover the capital costs. We then only have to provide the staff effort that goes along with that. For most of our major ongoing projects, then the capital contributions, certainly over the next year, have been covered in a very helpful way through this top-slicing mechanism that we discussed earlier as part of the partitioning of our programme.

The main concern that I have in terms of capital is the ability to start new things. That is not part of the university grants' portfolio but simply the ability to access money from the Large Facilities Capital Fund, for example, which is severely constrained in future years.

I remind you that the capital allocation was made for one year only and indicative afterwards. You can read

into that that it could go up or down, but we are certainly making the case that this level of capital investment is not sustainable for long if we want to maintain the high level of our programme and its world competitiveness.

Q148 David Morris: What role do the STFC staff have to play in promoting outreach and inspiring an interest in science? Can you allay concerns expressed to us, for example, from some staff at Daresbury Laboratory that "one of the first casualties as resources fall is outreach"?
Professor Mason: We have an outreach programme that is £1.6 million a year. In our planning, we maintain that at that level, so it has constant cash through the next four years. We have taken a deliberate policy decision not to hit our outreach programme because we regard it as so important. In addition to that, we are working with our research council colleagues to promote public engagement at the RCUK level. Again, that is very important.
Also, if you are talking about our internal staff as opposed to the staff in universities, we continually encourage them to talk to wider society, to tell them what they are doing. We arrange visits to our laboratories. Within our resources, we do as much as we can to give access to the general public, who, after all, have paid for these things, to be able to see what is going on and be inspired by that. We are developing new initiatives, some by leveraging other sources of funding, to push that agenda forward. I personally regard it as extremely important and I rarely encounter anybody who thinks differently.

Q149 David Morris: Do you think the previous financial problems of the STFC have dented morale within the research workers? Do you think that because of its previous difficulties, the relationship with researchers may have impacted on the goodwill of scientists to carry out outreach work?
Professor Mason: I hope not because it is not something they do for charity, but it is something that is in their interests too. Clearly, whenever you are in a difficult situation, as we have been, morale is going to suffer. That is inevitable. Hopefully, we are now in a position where we can start to rebuild and move forward. Let's not forget that what we have going forward is less than what we might have hoped for, but it is still an incredibly exciting programme. We are still involved in the most exciting elements of those, the top priority elements, and in a very strong way. We need to capitalise on that and ensure that the general public shares in the benefits of that investment, in the excitement and in the inspirational value of those things.

Q150 David Morris: The Association for Astronomy Education said in written evidence that it was a "false economy" for the STFC to reduce the amount of promotional and outreach material for schools that it produces. Why has the STFC reduced the publication of such material?
Professor Mason: I am not aware that we have, to be honest. We continue to produce the specific elements that were referred to in that piece of evidence and they continue to be available. Inevitably, over time, we are, will and should examine how we disseminate information. There is bound to be an increasing emphasis on computer media and more efficient ways—more effective ways, indeed—of distributing this information, but, in terms of the specific items that were referred to, my understanding is that we continue to produce them.

Q151 David Morris: You think that, instead of it being produced in hard copy format on paper, this is probably referring to it being distributed to schools.
Professor Mason: In this particular instance we continue to produce hard copy forms.
David Morris: You do.
Professor Mason: Yes. All I am saying is that, in general terms, one can expect that we would see a shift from hard copy forms to digital forms. As we all know, that is the way things are done these days.

Q152 Chair: Some of the big posters and things that are produced are going to continue to be produced.
Professor Mason: Yes. We are continually examining how to get the most effective impact from the amount of money that we have to spend on this.

Q153 Chair: Do you actively encourage scientists who you are supporting to engage in outreach work?
Professor Mason: Absolutely, and we always have. Within our new consolidated grants system, which both improves efficiency, going back to an earlier question, and gives university researchers a lot more freedom to set their own agenda, we are encouraging them to conduct a proportional amount of public engagement.

Q154 Chair: This Committee would, I am certain, endorse that and encourage the research councils to keep working out of the silos, because that is hugely important to everyone.
Professor Mason: Absolutely. I agree 100%.

Q155 Stephen Metcalfe: Professor Mason, we have heard examples this morning that you have had a somewhat difficult relationship with the research community that you have been funding during your time at the STFC. As your tenure draws to a close, is there anything that you believe you should have done differently that might have changed that relationship? Would you give any advice to your successor on how that relationship should be handled?
Professor Mason: I can only hope that my successor is in post in an easier climate than during my tenure. The STFC, as the previous witness acknowledged, is a very complex organisation. We had extreme pressures imposed on us from the 2007 spending review that were unanticipated by Government but, nevertheless, very real. I remind you that STFC was formed midway through the last spending review process. It was a very difficult situation to get up to speed on quickly and do everything right. However, I sleep easy at night that we did the best possible job that we could. There is a general consensus that we are improving our engagement with the community and improving it very rapidly.

It worked very well during this current spending review. Many people did an awful lot of hard work to get the outcome that we got in the spending review. That is work from Ministers, down through Adrian's people, to the research councils and also the support of and engagement with the community. We have to send a very coherent and clear message, as I said before, that money in this area is an investment; it is not a cost. It is something we have to do and it is very important. There have been difficulties in making those messages coherent and getting everybody to recognise that it is in their interest, for example, to be trumpeting the economic benefits of doing astronomy as well as the research elements and the intellectual arguments. It is a much more powerful argument if you can say, "This is essential for the country" rather than something that is just for intellectual appearance.

Q156 Stephen Metcalfe: Absolutely, but you would not have done anything differently from the way you have done it.
Professor Mason: There are details in which I would have done things differently. There are always going to be lessons learnt. Nobody ever gets it perfectly right, but in terms of the general direction of travel, we have come from a very difficult place to a place where it is relatively healthy and we can build for the future. I am very satisfied with our progress.

Q157 Stephen Metcalfe: So your successor, who I touched upon earlier, will be taking over in a better climate, you believe, than when you were first appointed.
Professor Mason: Who knows? I would certainly hope so because I wouldn't wish it on anybody else.

Q158 Stephen Metcalfe: No. When do you imagine that process to start?
Professor Mason: Perhaps Adrian should answer that.

Q159 Stephen Metcalfe: Do you believe that it should be fully open and transparent, and will you have an involvement in that?
Professor Mason: The answer is no, I won't have an involvement in that, but Adrian should take that question.
Sir Adrian Smith: BIS will take that forward in conjunction with the STFC council, in particular with Professor Mike Sterling. The process of thinking about the timetable, etcetera, is already in hand.

Q160 Stephen Metcalfe: What about being "fully open and transparent"?
Sir Adrian Smith: I am not quite sure what you mean. The law of the land requires us to be fully open and transparent in placing job descriptions and in process. These things are overseen in a very close way to make sure that all proprieties are met and that there is openness. We have no choice.

Q161 Stephen Metcalfe: Sir Adrian, the Wakeham review recommended that the composition of the STFC council should "redress the balance between the executive presence and the non-executive oversight." Do you believe that that has now happened—that the composition has changed?
Sir Adrian Smith: Yes.

Q162 Stephen Metcalfe: You are happy with it and BIS is happy with it.
Sir Adrian Smith: Yes.

Q163 Stephen Metcalfe: Who controls the appointment of those members on the council? Is that BIS or the STFC itself?
Sir Adrian Smith: There is a joint process to identify and attract people for council posts. Ultimately and constitutionally, they are signed off by Ministers but, clearly, the appointment process, the talking to people and the use of head-hunters means that we generate as much interest among the wider community as possible.

Q164 Stephen Metcalfe: So it is a BIS-led process rather than conducted by the council itself.
Sir Adrian Smith: Ultimately, it is BIS and it is signed off by Ministers, but, clearly, with close involvement of the chairman of the council.

Q165 Stephen Metcalfe: I have one final question. When will the STFC start publishing its minutes of its council meetings again?
Professor Mason: The STFC does publish the minutes of its council meetings as a general policy. There was one glitch from last April where, for some reason, it did not. It got stalled, but even those minutes are now published, but we always have done and always intend to.

Q166 Graham Stringer: Professor Smith, what is the balance between scientists and non-scientists on the council?
Sir Adrian Smith: The current balance?
Graham Stringer: Yes.
Sir Adrian Smith: I happen to have the list of the current council in front of me. There are five people who would be recognised as scientists. I would regard Professor Mike Sterling as, even though technically an engineer, in the category of engineering science academics. I would say there are six members on the council who I would view as scientists.

Q167 Graham Stringer: Out of how many?
Sir Adrian Smith: 11 or 12.
Professor Mason: There are 11 currently. There is one vacancy.
Sir Adrian Smith: 11.

Q168 Graham Stringer: Do you think that balance is right?
Sir Adrian Smith: Yes.

Q169 Graham Stringer: It is different from the balance on the other councils, is it, where there are more—
Sir Adrian Smith: No. There are 8 out of 16 at BBSRC. It is about the same ratio, is it not?

Q170 Graham Stringer: What about the other councils?

Sir Adrian Smith: I don't have those figures in front of me, but I would think it is about the same.

Chair: Thank you, gentlemen.

Written evidence

Written evidence submitted by the Government (APP 00)

Introduction

1. Astronomy and particle physics fall under the remit of the Science and Technology Facilities Council (STFC). In common with other Research Councils, STFC's discretionary capital budget allocation following the recent Spending Review has been cut by around 40%. Nevertheless, over the next Spending Review period, STFC's indicative capital allocation provides around £70 million for its core programme, £88 million for cross-Council facilities and £132 million to fund international subscriptions. In addition, the Spending Review settlement also confirmed that the Diamond Light Source facility in Oxfordshire will receive £69 million of public funding over the Spending Review period for further development in partnership with the Wellcome Trust.

2. STFC understands the need for economic reform, has welcomed its overall SR10 settlement, and recognises the Government's strong support for its science and technology programme. STFC carried out a thorough prioritisation of its programme in 2009 which focused support on its highest priority activities. This forms the strong basis of the STFC's Delivery Plan for the next four years.

The Impact of Reduced Capital Funding on UK Capability

3. STFC is responsible for several major capital facilities. Much of its capital budget in the last Spending Review period was spent on maintaining and developing facilities that support the UK research base. With the support of the other Research Councils, STFC has been allocated sufficient operating capital to make the running of these facilities sustainable, through the capital allocation for UK facilities. STFC has worked closely with BIS to re-evaluate its capital needs, reassessing priorities, identifying funds to sustain its world leading facilities and the changing requirements of the international subscriptions to CERN and the European Southern Observatory (ESO). The reassignment between capital and resource funding in its allocation reflects the changing profile of those requirements over time.

4. Nevertheless, the reduced capital available will potentially have impacts on programmes such as accelerator R&D, the Muon Ionisation Cooling Experiment (MICE) at RAL, and funding for equipment in university grants. In all these areas capital spend will be reduced. STFC is currently developing an implementation plan to focus the available capital on the highest priority projects.

Impact of Withdrawal from International Ground-Based Facilities on the UK's Research base and International Reputation

5. The cost of providing world-leading facilities for astronomy is escalating as the demands of the science increase and, recognising this, early in the last decade the UK decided to join ESO in order to benefit from shared developments with the UK's European colleagues. The cost of the UK's accession to ESO was to be found partly from savings resulting from withdrawal from existing ground based telescopes on La Palma (the Isaac Newton telescopes) and Hawaii (Gemini), and partly by additional funding. Ongoing commitments meant that withdrawal took a decade to complete, and STFC's policy for the Hawaii and La Palma telescopes is therefore the consequence of decisions made some years ago.

6. STFC's priorities in ground-based astronomy were set following input from a dedicated ground-based astronomy review panel, commissioned by STFC in 2009 and chaired by a former President of the Royal Astronomical Society. This panel carried out a detailed community consultation. STFC also sought advice from STFC's standing science advisory panels, which include practising UK astronomers. They gave a higher scientific priority to STFC exploiting its investment in ESO (with facilities in Chile) than to STFC's older investments in Hawaii and the Canary Islands. This confirmed STFC's policy in this area.

7. STFC's withdrawal from Gemini followed the recommendations of the ground based astronomy panel. The lower priority of Gemini in comparison with ESO reflects the more complete nature of the ESO package together with concerns about the long-term sustainability of Gemini as a world-leading facility.

8. The research community has made it clear to STFC that there is still scope to undertake good optical and infrared wavelength science research in the Northern hemisphere. STFC has been able to extend its support for the UK Infrared Telescope (in Hawaii) through to 2013 by making significant economies in its mode of operation. STFC continues to operate STFC-owned facilities in Hawaii (JCMT, UKIRT) and the Canaries (ING) and it is discussing future management arrangements with new partners (Hawaii) and with Spain (Canaries) which may include access to some if not all of these facilities. STFC's science committees will have to consider the case for continued UK investment in these facilities in competition with other demands on its science programme budget.

Engagement with the Research Community in these Two Areas on its Strategic Impact and Impact of Budget Reductions

9. During the prioritisation of its programme in 2009 and in preparing and developing its submission to BIS for the recent Spending Review, STFC worked closely with its research community. These include its Science Board, which advises on all aspects of STFC's science and technology programme, supported by its science committees—the Particle Physics, Astronomy and Nuclear Physics Science Committee (PPAN); and the Physical and Life Sciences Committee (PALS),working in close collaboration with their respective advisory panels.

10. Alongside this, STFC has held regular meetings and consultations with learned societies such as the Institute of Physics (IoP), and the Royal Astronomical Society (RAS), and held regular town hall meetings with the particle physics, nuclear physics and astronomy communities. STFC has consulted closely with its international partners, CERN, ESRF, ESO, ILL, universities, Diamond, and other Research Councils. STFC has made a clear commitment in its Delivery Plan to developing these relationships further.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

11. In its Delivery Plan, STFC has confirmed the commitment that it made in the outcome of the prioritisation of its programme in 2009 to sustaining support for public outreach and science communication. STFC will achieve this by funding projects and personal fellowships, particularly supporting researchers via facilitation and training, to:

- — inspire and enthuse new generations about science
- — encourage them to continue study in science, technology, engineering and mathematics (STEM) subjects
- — improve public understanding of scientific advances

12. STFC will work with RCUK in the collective Research Councils public engagement programme, and will maintain a distinct STFC-led programme focused on its research areas. STFC will also work in partnership with the UK Space Agency given the thematic closeness of astronomy and space science.

13. STFC will maintain resource spending on grants and keep studentship numbers constant in astronomy and particle physics, and will introduce a new Fellowships scheme and a new Studentship Enhancement Programme to nurture future research leaders.

February 2011

Written evidence submitted by Royal Astronomical Society (RAS) (APP 11)

1. In recent years UK astronomy and space science has been in a strong position. One measure of this is the productivity of UK researchers, who between 1999 and 2009 published 18,288 papers that received 330,311 citations, making us the most highly-cited nation after the USA.

2. The RAS welcomes support for our science from government, for example the decision of BIS to continue the implementation of the Drayson review. This addressed specific issues associated with the Science and Technology Facilities Council (STFC), such as the difficulties posed by changes in exchange rates and Net National Income (NNI) which determine the subscriptions paid by nations for the membership of international projects such as the European Southern Observatory (ESO) and CERN. We further welcome the steps taken to tackle the issue for STFC posed by the costs of domestic facilities used by a number of Research Councils.

3. However, the Comprehensive Spending Review and resulting allocations for the science budget plan for a steep reduction in STFC resource funding for astronomy over the period from 2011 to 2015. The impact of this flat cash settlement will depend on the level of inflation over the same period, but is expected to be of the order of 10–15%. Furthermore, as the cuts resulting from the 2007 CSR are implemented astronomy will see an additional decline in cash terms of around 11% by 2015, with resource funding falling from £81.4 million to £72.7 million and hence a total loss of purchasing power of 21–26%. This retrenchment threatens to cause irreversible damage to the UK astronomy and space science programme.

Impact of Reduced Capital Funding on UK Capability

4. In *capital* terms, STFC and hence UK astronomy faces an even more severe reduction. According to the material supplied by STFC to the Committee, the capital available for each of the financial years from 2012–13 to 2014–15 will be 56% lower than in 2010, declining from £23.27 million to £10.57 million.

5. This is a change which takes some time to work through the system, in that it affects existing infrastructure, such as the renewal of equipment as well as the ability to participate in new projects including the development of new instrumentation for observatories vital to our national capability.

6. Researchers in universities often bid for funds for small scale laboratory equipment and computers. These count as capital investment and are therefore likely to be seriously affected by the planned cuts.

7. Other areas of concern are magnetohydrodynamics, theoretical astrophysics and cosmology, all of which use High Performance Computing facilities to model different physical problems. This has been an area in which the UK excels and includes facilities in Durham, Leeds, Warwick and St Andrews. The supercomputers that are crucial for this work become obsolete as technology and potential computing performance advance, so periodically researchers need to renew this equipment. Any future applications for grants relating to this research may thus also fall foul of restrictions on capital.

8. Alongside STFC funded research, space scientists receive some funding from the new UK Space Agency. For this group the major capital costs associated with research projects are the spacecraft and its launch vehicle. With the Agency delivery plan not yet published, we are concerned that its budget will not be sufficient to cover its inherited responsibilities.

9. The cut in resource funding means that the UK is about to lose a competitive advantage it enjoyed through participation in facilities across wavelengths, in both hemispheres, on the ground and in space. In combination with the capital cuts, this risks causing long-term damage to the astronomy research base.

Impact of Withdrawal from International Ground-based Facilities (for Example the Gemini Observatory and Isaac Newton Group of Telescopes) on the UK's Research Base and International Reputation

10. In the near future (in most cases by spring 2012) the UK plans to withdraw from all optical and infrared observatories in the northern hemisphere. These facilities include the Isaac Newton Group (ING) and Liverpool Telescope (LT) on La Palma in the Canary Islands and the UK Infrared Telescope (UKIRT) and Gemini North telescope on Hawaii. The UK will continue to have access to ESO in Chile.

11. These plans result from a prioritisation exercise carried out by STFC in 2009. Despite scientific panels advising against this withdrawal, the research council made these decisions in order to manage a decline in its funding that resulted from the 2007 CSR allocation.

12. The UK is a partner in a number of existing and future space-based observatories, such as the Herschel Space Observatory, Planck, GAIA and the James Webb Space Telescope, all of which observe objects across the whole sky.

13. In addition there a number of flagship radio observatories in the northern hemisphere such as Jodrell Bank and the Multi-Element Radio Linked Interferometer Network (e-MERLIN) and LOw Frequency ARray for radio astronomy (LOFAR) arrays.

14. Once the cuts take effect, UK researchers will be able to use these space-based and radio observatories to study objects in the northern part of the sky but will have no optical and infrared facilities with which to follow up that work. These changes will mean that UK scientists who make discoveries using a space based or radio observatory could then see leadership of this work pass to their peers in other nations.

15. In contrast to the UK, the ESO member states Germany, Italy, France, the Netherlands and Spain all have access to other optical/infrared facilities elsewhere in the northern hemisphere. We are concerned that the decision to rely solely on ESO facilities is moving us from the first to the second division for UK astrophysics (involvement will be comparable to that by Portugal) and that it will further mean that we have much less to bring to any new international partnerships.

16. The decision to pull out from and certainly the abruptness of the withdrawal from the Gemini Observatory in 2007 has also undoubtedly had a negative impact on the reputation of the UK as a reliable international partner and may hinder our ability to join future collaborations.

17. In consultation with our Fellowship, we have established that there are a number of areas like stellar astrophysics, studies of gamma ray bursts and searches for planets around other stars that will be badly affected by the planned cut in provision. This work, where the UK is in a world-leading position, is particularly dependent on access to a suite of telescopes in both hemispheres.

18. Further support for this perspective comes from the STFC Ground-Based Facilities Review led by former RAS President Professor Michael Rowan-Robinson which reported in 2009. His panel surveyed the UK astronomy community and evaluated different observatories operating at optical, infrared, submillimetre and radio wavelengths. The Review accepted that withdrawal from Gemini was inevitable, but backed continuing UKIRT operation and instrument development and urged STFC to find solutions for UK access to large telescopes elsewhere in the northern hemisphere.

19. The Review panel also supported continued involvement in the ING, in particular citing the use of the William Herschel Telescope (WHT) to support follow-up work and provide a test-bed for instrument development. A continuing presence on La Palma could allow the UK to negotiate access to the Gran Telescopio Canarias (GTC), a telescope with a 10-m mirror operated by Spain, Mexico and the US, that is yet to come into full operation.

20. In addition, the 2010 report by ASTRONET (which brings together national agencies, including STFC, to develop a pan-European approach to astronomy) described a range of scientific programmes that could be carried out on the WHT in the years ahead, in part complementing the work of new space-based observatories.

21. Measures of the productivity of different observatories also support continued involvement in the ING telescopes. In a paper in "Astronomische Nachrichten" in 2008 Trimble and Ceja evaluated astronomical facilities around the world. The table below compares publications resulting from the 4-m mirror William Herschel Telescope (WHT) and 2-m mirror Isaac Newton Telescope (INT) and two other similar instruments.

Publications and citations resulting from medium-sized telescopes

Telescope	*Papers (from 2001–03)*	*Resulting citations (from 2002–06)*
Isaac Newton Group	246	2,962
Kitt Peak National Observatory 4-m telescope	79	1,244
Cerro Tololo Inter-American Observatory 4-m telescope	96	1,198

22. It can be seen that the ING compares favourably with the other facilities. Given this productivity, it is unsurprising that it is highly regarded by the research community and that consultation for this RAS submission elicited strong support for continued UK involvement in La Palma.

23. Current operational costs for the ING site are around €3.5 million (£2.9 million) per annum, with €1.3 million (£1.08 million) of this paid by the UK. This budget has already been pared to a minimum and funds only a limited operation. A more realistic UK contribution for full operations is around €1.5 million (£1.26 million) per annum. To remain competitive in the future the observatory needs to develop new instruments such as the new wide-field multi-object spectrometer which is now under consideration. A sensible figure for the annual UK budget requirement is €2.5 million (£2.1 million) per annum. Without an investment of this kind to recover access to northern hemisphere facilities we fear that UK astronomy will be internationally uncompetitive.

Whether the Science and Technology Facilities Council (STFC) has Sfficiently Egaged with its Rsearch Community in these Two Areas on its Strategic Direction and Impacts of Budget Reductions

24. There is a consensus that STFC has made real efforts to improve its engagement with the research community from 2009 onward. The prioritisation exercises that informed recent funding decisions drew on the advice of research scientists organised into thematic panels, although in key respects they did not follow this advice.

25. Senior representatives from STFC are also regularly invited to attend the Astronomy Forum, the body convened by the RAS made up of heads of astronomy and space science research groups across UK universities.

26. The astronomical community sees the origins of the STFC crisis as dating from its formation in 2007. At that time decisions on programmes and grants resulting from a budget shortfall of some £80 million were announced with little or no consultation.

27. Examples of community tension at that point included political and media campaigns such as the petition to Downing Street which attracted almost 20,000 signatures urging the then Government to mitigate this shortfall. In April 2008 the House of Commons Innovation, Universities, Skills and Science Committee (which covered the work of the present Science and Technology Committee at that time) found weaknesses in STFC management, communications and its peer review system. The Committee recommended substantial and urgent changes to the Research Council to restore confidence in its operation and to give it the leadership it needed.

28. Despite welcome changes, there is however still concern that at the most senior level, STFC does not act as an advocate for science in the way that it might. This came across starkly in the Select Committee hearing on the Research Council budget allocations, where the STFC Chief Executive Officer made statements which require clarification as they left a misleading impression.

29. Firstly, the Society disputes the assertion that there had been a planned over investment in astronomy following the UK accession to ESO in 2002. This is in contrast to the recollection of the scientific community and not supported by any documentary evidence that we are aware of. On the contrary, areas like grant funding (at least measured by the number of postdoctoral research associates hired) have seen a 50% decline since 2006 and are now lower than in the year 2000.

30. Although very different funding systems make international comparisons hard to make, the number of members of the International Astronomical Union is a reasonable measure of research activity in different countries. Adjusted for population size, the UK is very much in the middle of the table, with 8.4 members per million people, compared with 12.3 in the Netherlands and 4.7 in Japan. We also note that in the five years leading up to 2008, the UK astronomy community grew by 14%, in line with the overall expansion of higher education. Both these pieces of evidence suggest that the UK does not have too many astronomers.

31. Our second serious concern is around the withdrawal from all northern hemisphere optical and infrared observatories referred to earlier in this submission. The evidence given to the Committee implies that this decision was also planned following ESO accession and is part of a long-term scientific strategy. The RAS notes that when the UK joined ESO it was recognised that we would scale back our involvement in some facilities (see for example the report by Professor Martin Ward in 2001 in "Astronomy and Geophysics"), but the plan now being implemented goes far beyond that. The decision to implement a complete withdrawal was made for financial rather than scientific reasons, in contrast to the statement made to the Committee.

32. The Committee may also wish to note that the STFC Council has an unusually low number of members with an academic background, in contrast to the other Research Councils. Given that the scientific advisory panels sit some way below the decision-making committees in STFC, recruiting more scientists to its Council to better reflect the balance of research funded would only lead to a modest increase in its size and we feel would also assist in the overall engagement process.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

33. Astronomy is recognised as being an ideal subject for engaging young people and the wider public in science. Evidence for this includes the study by Osborne and Collins published in 2000, which examined the views of pupils and parents on the school curriculum and found that astronomy and space generated "universal enthusiasm". Studies that looked at the impact of specific outreach projects in astronomy and space science on school pupils and found a similarly positive effect.

34. At university level, the Institute of Physics surveyed physics students in 2007 and found that 53% of undergraduates saw astronomy as being of "significant interest" in attracting them to the subject; by the final year this rose to 73%.

35. More generally, astronomy is a popular topic for broadcast and print media, with a good recent example the TV series "Stargazing Live", which attracted more than three million viewers.

36. The Society recognises that in contrast to some other Research Councils, STFC has a good record of promoting public engagement through the Science in Society programme. The long-running small and large awards schemes encourage researchers to engage in outreach programmes that promote the areas of science funded by the research council, although funds available for these have declined. We also strongly support the STFC Science and Society Fellowships that allow active researchers to spend the equivalent of one day a week over the course of a year pursuing public engagement work.

37. Some third sector organisations also fund astronomy outreach, including the RAS, which awarded £180k to 89 projects taking place as part of the International Year of Astronomy 2009 (IYA 2009), but more typically offers around £25k per annum.

38. Activities in astronomy public engagement work often celebrate particular events like the 50th anniversary of human space flight this year (Gagarin 50) or the 400th anniversary of Galileo's use of the telescope in IYA 2009. That year saw almost a million people take part in events run by both research staff and voluntary and community groups.

39. Other work runs over the longer term, such as the National Schools Observatory (NSO) that allows schools to access time on professional observatories via the Internet or the engagement programmes of science centres like the Royal Observatory Greenwich (ROG). The NSO has almost 2,000 teachers and 3,500 pupils registered as users who typically make 620 observing requests each month. Each year the ROG hosts 14,000 school pupils and almost 1.6 million visit the site, making it one of the most popular tourist attractions in the UK.

40. We believe that such a vibrant public engagement programme depends on a vibrant research programme. Although the majority of participants in astronomy engagement programmes and projects will not pursue the subject in higher education, many established scientists in other disciplines cite early exposure to astronomy as a motivating factor for a STEM career. In particular, although it is too early to assess, there is a risk that scaling back research activity and the opportunities that come with it will harm the perception of UK science with young people who may then seek other career paths.

41. On many measures, astronomy is in the midst of a "golden age". In the decades ahead, new facilities like the European Extremely Large Telescope and the James Webb Space Telescope are expected to lead to a flood of new discoveries, for example enabling us to see Earth-like planets in orbit around other stars and to detect the first stars that formed after the Big Bang.

42. Cutting-edge research of this kind provides great opportunities to inspire a new generation of scientists and it would be unfortunate if the UK did not continue its involvement in this work.

43. We recognise and applaud the efforts made to limit the cut in the number of STFC-funded PhD studentships in astronomy, which declined by 15% over the last four years but should remain at 122 for this CSR period.

44. One clear area where opportunity is tightening is in postdoctoral posts in astronomy. These have declined by more than 50% since their peak, from around 120 in 2006 to 56 in 2011. The Society is concerned that this will deter the best PhD students and research leaders from remaining in the UK.

Royal Astronomical Society

16 February 2011

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Written evidence submitted by Robert Kennicutt, Plumian Professor and Director, Institute of Astronomy, University of Cambridge (APP 12)

I am writing to offer views on the four points raised in your recent inquiry on astronomy and particle physics. As introduction I hold the Plumian Chair at the University of Cambridge and since 2008 have served as the Director of the Cambridge Institute of Astronomy. Since our Institute is funded by the STFC I clearly have an interest to declare, though I submit these views on my own behalf and neither as a representative of the IoA nor the University. Prior to 2005 I worked in the US (where I am a member of the National Academy of Sciences), and I continue to participate in numerous science policy activities there and internationally. As such I believe I can offer both a local and an international perspective on the issues raised in your inquiry.

The Impact of Reduced Capital Funding on UK Capability

1. Much of this funding is used to support small to medium-scale instrumentation and telescope projects. My greatest concern is that should there be an extended period of sharply reduced funding in this area, the UK will suffer a permanent loss of leadership and skilled scientists in astronomical instrumentation. This is an area of astronomy which provides excellent value for money (because of the large amounts of international funding it attracts), and one with strong links to UK industry and the high-tech economy. The UK currently hosts a number of world-class instrumentation groups (eg Cambridge, Cardiff, Durham, Edinburgh, Oxford, UCL/Mullard) which compete successfully for EU-funded projects (ESO, ESA), and assure UK leadership in the projects as well as attracting outside funding for UK-built projects. Our system is resilient enough to absorb short-term losses in funding (as we have over the past three years), but a long-term major funding cut, while institutions in Germany, the Netherlands, and elsewhere are building up their capabilities, will jeopardise UK leadership in this area, and force restructuring with the risk that some groups will go out of business for good.

The Impact of Withdrawal from International Ground-based Facilities (for Example the Gemini Observatory and Isaac Newton Group of Telescopes) on the UK's Research Base and International Reputation

2. I can speak with some expertise on this matter, as I served as the Vice-Chair of the STFC's Ground-Based Facilities Review (GBFR) panel. That panel conducted a broad consultation exercise with the UK research community and recommended priorities for facilities which (we are told) formed the basis of the subsequent decisions by the STFC Executive. The Chair of the GBFR panel, Professor Michael Rowan-Robinson, has submitted a separate document on this subject, so I shall only highlight a few key points here.

(a) The withdrawal from the Gemini Observatory was based on cost-effectiveness considerations and recognition by our research community that overall savings in facilities costs would need to be realised to meet national budgetary pressures and to make funding headroom for future projects. It was not based on any southern hemisphere strategy, as has been alleged before your Committee. To the contrary, the loss of northern hemisphere access was recognised as a major problem that needed to be addressed via other facilities (below).

(b) The GBFR panel recommended that if the UK did withdraw from Gemini, access to other large UK facilities in the northern hemisphere (eg, ING telescopes) be preserved, at least through mid-decade. We also recommended that STFC arrange for a small allotment of time on other northern hemisphere telescopes, to mitigate part of the loss of northern hemisphere access from Gemini. Since the GBFR was released the STFC has moved forward with its recommendation on Gemini withdrawal, but it is not yet clear whether it intends to honour the other recommendations which were intended to mitigate the impacts of this withdrawal (at a small fraction of the cost savings from our other recommendations).

(c) Speaking directly to the question, I believe that withdrawal from Gemini can be accomplished without serious damage to the UK research base or international reputation in astronomy (while admitting that our community is not unanimous in this assessment). The same can be said for other facilities which were ranked at or near the bottom of those reviewed by the GBFR; the panel's rankings generally mirrored those in our polling of the community. However if the closures were extended to other facilities which were highly ranked in the GBFR (for example the Isaac Newton Group of telescopes), there would be serious damage, in particular for subjects which rely heavily on those facilities (eg, exoplanetary astronomy) and for support of current and future UK-led space missions such as the Herschel Space Observatory an the Gaia mission.

Whether the STFC has Sufficiently Engaged with its Research Community in these Two Areas on its Strategic Direction and Impacts of Budget Reductions

3. I regret to say that a disturbing disengagement—sometimes bordering on an adversarial relationship—has developed between the STFC Council and its research community. By contrast interactions and communications between the Science Programmes Office and Astronomy Division to the community remain strong, with regular exchanges through the standing STFC panels and an informal Forum with astronomy group leaders (via the Royal Astronomical Society). However the STFC Council itself often appears to be out of touch, most of all its Chief Executive. Some level of tension between these groups is inevitable and necessary, of course, and the financial pressures present since the STFC was formed have not helped; but the level of disengagement and acrimony that I have seen here is unlike anything I have observed in 30 years of professional life in the US and UK. Although many will claim to have a simple explanation for this state of affairs, I believe its origins are complex and include irrationalities in the structure of STFC when it was formed, insufficient core scientific representation on its Council, and a leadership vacuum from its Chief Executive.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

4. I believe that the question actually understates the opportunities before us. Astronomy has long served as a "gateway" science for young people, one that attracts and inspires not only future astronomers and physicists but future engineers, chemists, and teachers as well. I see direct evidence for this in the thousands of people who attend our public evenings, open days, and schools programmes at the IoA every year. Today is a prime time to exploit this potential, as the pace of discovery in astronomy and particle physics has reached historic levels, and IT make it possible to connect the public to remote observatories in ways that were not possible even a decade ago. From my perspective the UK (along with most of the rest of Europe) was at least a decade behind the US in recognising the importance of this area, but in this case I credit the STFC with recognising the need, and promoting and fostering public engagement. Those are the opportunities, but I do see threats as well. Apart from the obvious need to maintain funding for the most effective programmes, it is important not to allow the distinction between the STFC's outreach mission and its core research mission to become too blurred. As a specific example that arose during the GBFR, facilities with outstanding outreach components such as the Liverpool Telescope ought to deserving of STFC support from its outreach funds, but if (as in this case) the importance of its core research is weaker, that support ought not to jeopardise the funding of other facilities on the research budget line. By the same token the allocation of outreach funds ought not necessarily be locked into the research facilities or projects pecking order. There should be room for fostering the very best science and the best outreach without forcing a marriage between the two at every level. The other threat I see, regrettably, is the impact of negative publicity regarding public support for science on the very young people we whom are trying to attract. In this area as with the others you raised, there is a dire need for leadership and a positive vision, which appears to be sorely lacking in the Council today.

Professor Robert C Kennicutt, Jr
Institute of Astronomy
University of Cambridge

15 February 2011

Written evidence submitted by the Institute of Physics (APP 17)

Astronomy and Particle Physics

The Institute of Physics is a scientific charity devoted to increasing the practice, understanding and application of physics. It has a worldwide membership of around 40,000 and is a leading communicator of physics-related science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

The Institute welcomes the opportunity to respond to the House of Commons Science and Technology Committee's inquiry into the impact of reduced capital funding on UK astronomy and particle physics research. The attached annex details our response to the questions listed in the call for evidence.

However, astronomy and particle physics research are not the only STFC funded areas affected, thus we have included an appendix to our response which focuses on nuclear physics and the impact reduced capital funding will have on access to international facilities.

If you need any further information on the points raised, please do not hesitate to contact us.

Professor Dame Jocelyn Bell Burnell
President

Professor Peter Main
Director, Education and Science

16 February 2011

The Impact of Reduced Capital Funding on UK Capability

1. The reduction in capital funding, as we understand it, refers not only to expenditure in relation to the construction of large facilities and upgrades to existing facilities, but also includes maintenance costs associated with existing facilities, and the funding available for university-based laboratory equipment. This is effectively a loss of flexibility in the use of capital across all areas of science supported by RCUK, which will disproportionately affect all of the research areas supported by STFC as it is the most capital intensive of the research councils. Such cuts can be coped with for a short period but if maintained for any length of time the decay in infrastructure will cause considerable harm to UK science. In relative terms, the UK will very rapidly fall back compared with its international competitor nations where investment levels are greater because they recognise the long-term value of science to their economies and quality of life.

2. The reductions in capital funding will make medium and long-term planning very difficult, whilst also affecting ongoing STFC funded research. Research in particle physics, astroparticle physics, astronomy and nuclear physics involves long timescales and careful planning. The development of equipment and facilities relies on capital expenditure at the appropriate point in the development cycle and cuts to funding for capital projects would provide uncertainty for future research projects.

3. STFC funds a considerable amount of work on accelerator beam technology R&D which is an essential prerequisite for the development of future international facilities. This work, which requires considerable capital expenditure, provides the science and technology infrastructure that underpins the facilities required to conduct the research. Some of this work is carried out in universities but much is located at the Daresbury Laboratory, and the Rutherford Appleton Laboratory. Currently, STFC does not have the requisite funds to invest in such R&D, which will lead to adverse consequences for the UK in the future. Thus a policy of capital investment in R&D projects is essential.

4. Reduced capital funding is likely to have a significant impact upon the UK's ability to take a leading role in the European Extremely Large Telescope (E-ELT), which is the next flagship ground-based telescope project for Europe. The UK belatedly joined the European Southern Observatory (ESO), preventing industry from benefiting from the construction of the Very Large Telescopes; in contrast it is hoped that a leading UK role in E-ELT would facilitate a significant construction role for UK industry, something a long-term capital reduction in funding may jeopardise.

5. There are concerns that space science, now split between the UK Space Agency (facilities) and STFC (exploitation) may not be sufficiently joined-up, with space science likely to suffer relative to space industry, given the relatively poor (capital) settlement for the UK Space Agency in the 2010 Spending Review.

6. Reduced capital funding is having a strongly negative impact on the development of astroparticle physics research within the UK. The field is growing rapidly internationally, and UK scientists, having played major roles in the early projects in the fields of dark matter research, ultra-high energy cosmic rays, ground-based gamma-ray astronomy and the detection of high-energy neutrinos, are being excluded from future participation by a lack of capital investment. Dark matter research, ultra-high energy cosmic-rays and ground-based gamma-ray astronomy are three areas in which the UK did much pioneering work and once held leadership roles which are being lost as the rest of the world has stepped in with better and more stable funding, but often using the

same technologies. Indeed, the UK is now viewed as an unreliable partner. This cannot be good for the UK at any level; a good reputation can be lost quickly but only slowly regained.

7. Given that STFC operates many major capital intensive facilities and that part of the international subscriptions is also classified as capital, any reduction in capital funding inevitably puts additional pressure elsewhere in a system which has never recovered from the £80 million deficit following the 2007 Spending Review. This pressure, and the direct impact of the reduction of capital funding for equipment, has presumably led STFC to propose in its Delivery Plan for 2011–12 to 2014–15[1] a significant reduction in support for university technology R&D and, instead, focus STFC's in-house researchers on technology, instrumentation and detector development, with the suggestion of leaving academics to concentrate on scientific research. However, this decision is based on a misconception of how cutting-edge science and its associated innovative technology are related. Most of the recent technology, instrumentation and detector delivery in particle physics, such as to the LHC experiments, has been led by university groups, and together they house most of the UK expertise and international leadership in this area. In addition, such a decision will make it much harder for the next generation of PhD students and PDRAs to get access to the latest equipment. For instance, will students based at a Scottish university travel to Harwell to get access to the latest Agilent scope, or do they simply train on equipment that is five years out of date?

8. Detectors in particle physics (and astronomy) can only be built successfully in close contact with those who use the data and understand the nature of the technical challenges and the reasons for the demanding technical requirements; this is how the rest of the world operates. Any attempt to make unilateral changes to this method of working would undermine UK leadership and innovation in detector technology, and may make it harder for UK industry to compete successfully for contracts. The reduction in support for university technology R&D also makes it difficult for universities to engage with programmes that deliver impact from their scientific endeavours, since this mainly comes from their own, in-house, technology development.

The Impact of Withdrawal from International Ground-based Facilities (for Example the Gemini Observatory and Isaac Newton Group of Telescopes) on the UK's Research Base and International Reputation

9. UK competitiveness in astrophysics and space science arises in large part from the multi-wavelength, multi-hemisphere facilities, both ground based and space based. Over the course of a few years, the UK lead in ground-based telescopes within Europe has been lost. The dismantling of the UK-led ground-based facilities is scheduled to be implemented during the 2010 Spending Review period. Recommendations from advisory panels and STFC's ground-based review panel noted that access to a northern hemisphere telescope beyond 2012 was of a high priority, in part due to current UK-led international space-based facilities (ie Herschel, Swift).

10. The forthcoming loss of island sites (i.e. La Palma, Hawaii), will greatly reduce opportunities for UK-led innovative instrumentation development. Of particular concern to astronomers is the UK's withdrawal from the La Palma site; for the UK, this hosts the Isaac Newton Group of Telescopes, SuperWASP and the Liverpool Telescope, all with significant STFC involvement. The scientific and technical synergy between the La Palma telescope facilities, operating at a world-class site, provides a range of unique opportunities for UK and international scientists. For example, ULTRACAM was the first visiting instrument at ESO's Very Large Telescope, which was only made possible after being commissioned at the Isaac Newton Group of Telescopes. In the specific case of the Liverpool Telescope, this instrument represents the world's largest and most capable fully-robotic telescope providing the UK and the international community with unparalleled opportunities for exploration of the increasingly important time domain of astrophysical enquiry, as emphasised in the latest US Decadal Survey.[2]

11. Similar concerns exist for UK particle physics research. For instance, the cancellation by STFC, in its 2008–11 Delivery Plan,[3] of UK participation in the International Linear Collider programme has damaged the UK's reputation as a reliable international partner. Its remaining activities are only possible because CERN has agreed to contract UK scientists directly to provide advanced equipment and technology, whilst other European nations participating understand the benefits of contributing from their own resources.

12. A possible UK involvement in the upgrades to the LHCb and SNO+ experiments, and many other opportunities, have been removed from the STFC roadmap for particle physics,[4] resulting in a very narrow focus which both stifles new ideas and initiatives and gives the UK a reputation (both internationally and to its own young scientists) for lacking vision and ambition.

[1] http://www.stfc.ac.uk/resources/pdf/dp2011–15.pdf
[2] http://science.nasa.gov/earth-science/decadal-surveys/
[3] http://www.stfc.ac.uk/resources/pdf/delplan_07.pdf
[4] http://www.stfc.ac.uk/Resources/PDF/PPANPriRepFin.pdf

Whether the Science and Technology Facilities Council (STFC) has Sufficiently Engaged with its Research Community in these Two Areas on its Strategic Direction and Impacts of Budget Reductions

13. The Institute appreciates the efforts made by STFC and EPSRC to engage with the physics community, particularly in the run-up to the 2010 Spending Review. Both research councils participated in town meetings at the Institute and discussed their hopes and fears for the science base and provided the community with an opportunity to raise its concerns about future prospects for specific research areas. STFC has also participated in another town meeting, held at the Institute on 10 February 2011, in order to allow the community to offer its views to inform STFC's Implementation Plan, which will translate the commitments in the STFC Delivery Plan for 2011–12 to 2014–15 into an Operations Plan by the end of March 2011; STFC is also working with its science committees to seek advice on a number of research areas.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

14. It is very important to inspire the next generation of scientists in a wide range of research projects at the forefront of the science in particle physics, astroparticle physics, astronomy and nuclear physics. This is essential to ensure future breakthroughs and to achieve recognition for the successes of UK physicists. While research in all these areas is now multinational, it is vital that UK physicists achieve and maintain leadership roles in the science if they are to inspire the next generation and convince them that science is an area which is worth devoting their lives to. In order to lead, research scientists have to be fully engaged and cuts to capital funding will be a major obstacle to achieving this objective.

15. Outreach in particle physics, astroparticle physics, astronomy and nuclear physics has never been in better health, spearheaded by Professors Brian Cox and Jim Al-Khalili but ably supported by a very large number of other scientists. Substantial media coverage in the broadsheets, the Internet and on television and radio backs up the very extensive work in schools—almost every day a STFC funded scientist is in a school somewhere in the UK enthusing young people to study physics and science in general. However, this level of outreach is undermined by cutbacks to the very projects schoolchildren find exciting.

16. The incorporation of the LHC into the national consciousness is something that has both amazed and delighted the UK's particle physics community. All particle physicists have had the experience of being able to engage with members of the public about fundamental science because they have heard of CERN and the LHC, and many are genuinely curious about it. We are also pleased to acknowledge the significant part played in achieving this by STFC, who invested a great deal in preparing for the launch of the LHC and whose Science in Society funding schemes[5] in outreach are extremely valuable. However, STFC has discontinued the production of a large range of charts, booklets and posters that had been extremely popular with schools and the general public; the Institute has attempted to plug the gap with the production of a number of reports on particle physics, nuclear physics and the central facilities (with financial support from STFC), but not at the level/volume previously undertaken by STFC.

17. As well as its primary research function, the Liverpool Telescope is central to the operation of the UK National Schools' Observatory[6] providing UK schools with access to time on this front-rank research facility which allows access to research-quality data for experimentation in the classroom. The main aims of the NSO are to inspire the next generation about the study of STEM subjects as a whole by harnessing young people's innate enthusiasm for astronomy. No other telescope that falls within STFC's (or ESO's) remit provides this opportunity for schools, and it would be hard to envisage a cost-effective way for the NSO function to be delivered via an alternative route. Currently, the NSO has over 2000 UK schools signed up. Of those, approximately 1,200 schools have been very active users in the last 12 months. Since November 2004, the NSO has delivered over 23,000 requests for Liverpool Telescope observations in total, of which 7,000 were in the last 12 months and 1,400 in the last month (ie a rapidly increasing level of activity).

18. Currently, the astroparticle physics community has hopes that a proposal for a Virtual Institute to promote the field will be supported at an adequate level by STFC. This initiative has come from constructive dialogue between the community and STFC over the past few months and from extensive intra-community debate. The community is making the case for what would be needed to play important roles in the next dark matter and ground-based gamma-ray astronomy projects. Participation in these projects will be of immense value to any UK outreach programme leading as well, of course, to the long-term involvement of the UK in future astroparticle physics projects.

19. In addition, the likely renaissance in nuclear power generation in the UK will clearly require many highly trained graduates, often at the doctoral level, in nuclear technology. It is vital therefore to have a thriving nuclear physics research community to inspire young people into nuclear physics and nuclear engineering. A strong outreach programme that demonstrates the impact of nuclear science should be considered by STFC.

[5] http://www.stfc.ac.uk/Public%20and%20Schools/1344.aspx

[6] http://www.schoolsobservatory.org.uk/

20. For early career researchers in particle physics and astronomy the picture is more mixed, including both opportunities and threats. Reductions in research grant support for both astronomy[7] and particle physics[8] will have the effect of reducing the competitiveness of such research with respect to rival nations and is likely to do long-term damage to the attractiveness of the UK for prospective postgraduate students, PDRAs and academics. New graduates are often encouraged to apply for PDRA positions overseas, especially for those seeking to embark upon an academic career, although a subsequent return to the UK would require competitive opportunities, which are at present lacking. This is despite astronomy and particle physics featuring heavily in the media and the government's ambitions to increase the number of scientists, engineers and physics teachers.

APPENDIX

THE IMPACT OF REDUCING CAPITAL FUNDING ON NUCLEAR PHYSICS AND UK ACCESS TO INTERNATIONAL FACILITIES

1. The physics community is also greatly concerned about the impact of a reduction in capital funding on nuclear physics research, and access to international facilities (particularly ISIS).

2. Since 1993, when the last UK nuclear physics facility was closed, there have been essentially no funding for nuclear physics facilities. In the past, major capital equipment was provided as a contribution in kind which was welcomed by the directors of international laboratories. In addition, the—£10 million per annum devoted to nuclear physics in 1993 has declined even in cash terms to a projected £6 million per annum for the coming years prior to any further cut following the 2010 Spending Review settlement. In terms of projects, prior to the 2010 Spending Review, nuclear physics had been reduced to one project to build a limited range of equipment for the Facility for Antiproton and Ion Research (FAIR) and a small part of the European Advanced Gamma Tracking Array (AGATA). UK nuclear physicists have little or no influence on the future of a research area that relies on large facilities, where planning, building, commissioning and exploitation can take decades.

3. At the same time nuclear physics is advancing rapidly elsewhere; major new facilities are being constructed such as FAIR (GSI, Germany), ISOLDE (CERN), SPIRAL2 (GANIL, France), and the Jefferson Lab (US). These facilities are important to UK nuclear physicists as they are where future advances in the field are most likely to be made; for instance, providing the beams of radioactive ions or high energy electrons needed to understand the structure of the nucleon, the wide variation in the properties of nuclei and the nuclear reactions fuelling stars and stellar explosions as well as the creation of the heavy elements. Unless the UK plays a major part in the development and operation of these facilities our nuclear physicists will be left out and will rapidly lose the leadership roles they currently possess. These facilities still require capital funding to complete some buildings and the equipment they house; if the UK was able to contribute capital funding in the region of £20–25 million to these projects spread over a five year period, the UK's standing and influence would be transformed.

4. ISIS has for some time been the leading neutron spallation source worldwide, playing a pioneering role and offering experimental possibilities not available elsewhere. The ISIS Target Station 2, a £147 million investment by the UK, has recently become operational and offers unique scientific opportunities in the areas of advanced materials, including biomaterials and soft matter. In response to a RCUK recommendation based on user demand, STFC plans to operate ISIS for only 120 days per year and with a limited suite of instruments. This is a significant reduction compared with the historic facility operation of 180 days per year.

5. While we recognise the budgetary constraints under which STFC is operating, we stress that recognising the outstanding contribution ISIS makes to the UK's capability in research and the potential of ISIS to deliver against the global challenges facing us today, ISIS should operate for a higher number of days to maximise its scientific output and the return on the UK's capital investment.

6. In addition, reduced capital funding will also have an impact on the construction programme of ISIS Target Station 2 instruments. The engineering basis underpinning these projects could quickly evaporate, and it would be exceedingly difficult to rebuild it. Currently, seven Target Station 2 instruments are either operational or in the process of being commissioned, out of a total capacity of 18 instruments. Four Phase 2 instruments, on Target Station 2, are currently awaiting a funding decision, which would also unlock significant contributions from international partners.

7. Although STFC has stated its intention to adequately fund the Diamond Light Source, it has unfortunately taken the decision to cut the UK's contribution to the European Synchrotron Radiation Facility (ESRF) and reduced the UK's involvement in Free Electron Laser (FEL) research to zero. At the ESRF, this will reduce exploitation from 14% to 10%, most probably leading to a hard cap to UK access; as a result, physics users of ESRF will be hit particularly hard and will also not be involved in the pioneering science which is arising from the FEL research frontiers.

The Institute of Physics is a scientific charity devoted to increasing the practice, understanding and application of physics. It has a worldwide membership of around 40,000 and is a leading communicator of physics-related

[7] A reduction in the award of PDRA positions coupled with the withdrawal of independent junior—postdoctoral—STFC fellowships.

[8] The removal of funding from awarded research grants from October 2010, and the issue of awarding just one-year grants prior to that.

science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

Supplementary written evidence from the Institute of Physics (APP 17a)

i) Particle Physics Budget

1. In 9 March 2011 oral evidence session, Gavin Barwell MP queried the increase in the resource allocated to particle physics and its justification. The increase in particle physics "resource" is a displacement from shortfalls in the allocation of "capital"; in terms of both human capital and R&D, the particle physics resource has declined sharply in the past five years. Below we offer a more detailed response to this.

2. Appendix D[1] of the STFC Delivery Plan for 2011–12 to 2014–15 is shown below. In total this shows an increase of approximately £15 million over the period 2011–12 to 2014–15. This increase covers the "resource" element of the particle physics budget.

APPENDIX D OF THE STFC DELIVERY PLAN: RESOURCE BUDGET BY THEME
(£M)

	2011–12	*2012–13*	*2013–14*	*2014–15*
Particle Physics				
International subs—CERN	81.81	89.36	90.45	92.43
Development	11.12	11.44	12.97	14.15
Operations (M+O) & exploitation	30.50	30.56	30.87	31.84
Studentships and fellowships	9.80	9.70	9.59	9.79
Total Particle Physics	**133.23**	**141.05**	**143.89**	**148.21**

3. "Operations (M+O) & exploitation" funds the grants (mostly to universities) that support core technical staff and PDRAs. This shows a modest increase of £1.4 million (5%) and given the prevailing inflation rate is likely to result in a net reduction in PDRAs. The majority of the increase in the particle physics "resource" is in the CERN subscription; however, this has to be considered together with the "capital" line. The CERN subscription will in fact have a net decrease of approximately £20 million[2] over the next five years after CERN announced expenditure decreases in December 2010 in response to the economic downturn.

4. The Drayson Review recommended that the international subscriptions including the CERN subscription be ring-fenced in the Science Budget. The CERN subscription is paid from both the "resource" line (see Appendix D) and the "capital" line. The significant reduction in STFC's "capital" budget has meant that more of the CERN subscription is now being paid from the "resource" line. In 2010–11 £63.6 million of the £96.5 million CERN subscription was paid in "resource", however, in 2011–12 this rises to £81.8 million and £89.4 million in 2012–13. The increase in "resource" spent on the CERN subscription is due to the significant reductions in "capital" budget. In 2010–11 £58.5 million of STFC's subscription (£32.9 million to CERN) came from the "capital" budget. This £58.5 million is reduced to £46.2 million in 2011–12 and becomes £27.6 million in 2014–15. In essence an additional £30 million of international subscriptions (around 50% of this in the CERN subscription) in 2014–15 will be paid from "resource" line compared to 2010–11 to ensure the subscriptions remain "protected" in light of the significant reductions in capital budgets.

5. Thus, as already mentioned, the noted increase in particle physics "resource" is simply a displacement from shortfalls in the "capital" allocation; in terms of both human capital and funds dedicated to R&D, the particle physics resource has declined sharply in the past five years. Even before the merger of PPARC and CCLRC to form STFC, a reduction of 15% in PDRA and technical staff posts was implemented in 2006. Subsequent cuts as a result of STFC's two prioritisation exercises have further reduced the number of PDRA and core technical staff by 33% resulting in a net reduction between 2005 and 2010 of over 35%. The "flat-cash" Operations & Exploitation resource allocation, with a 5% inflation rate, will result in a further 10% cut over the Spending Review period such that over a 10-year (2005–15) period particle physics, in terms of human capital, will have been cut by 50%. This is in contrast with our international peers.

6. In addition to cuts in human capital, R&D budgets—a significant fraction of which are predicated on "capital"—have been cut significantly. In 2011, particle physics has only three R&D projects in receipt of significant funding: SuperNEMO; CERN/LHC-upgrades; and MICE. The funding for these projects beyond 2012 is uncertain and the lack of breadth (and vision) in funded research is again in stark contrast to our international peers.

7. Our peers continue to invest in the next generation of particle physics experiments owing to their potential to stimulate growth and to train the next generation of engineers and physicists skilled in precision mechanical engineering, digital electronics, distributed computing and advanced numerical analysis. A review[3] of over 150 companies involved in the construction of the LHC highlighted that 38% of the companies developed new products, 42% increased their international exposure and 44% improved their technology-based knowledge. The return on the investment in CERN is very similar to that from investment in ESA, ie that every £1 invested in a company returns approximately £3 to the company in terms of new contracts and enhanced capabilities.

The companies engaged with ESA mostly enhanced their market share in the space industry whilst companies engaged with CERN predominantly enhanced their market share in sectors outside of particle physics. In some cases the returns on innovations in particle physics are rather rapid (eg the world-wide web invented at CERN in 1989) and some are on a longer timescale; for example, the capacitive touch-screen now used on all smart phones was developed at CERN[4] in the late 1970s. Current developments[5] in particle physics include bespoke accelerators for cancer therapy (using protons) and micro-electronics as retinal prosthetics to restore sight to patients suffering from degenerative retinal diseases.

ii) The Proposal for a Virtual Institute

8. In addition, a question was asked in the oral evidence session about the Virtual Institute. This is an initiative by a group of astroparticle physics researchers to secure funding from STFC to help mitigate the current crisis in astroparticle physics research, by ensuring a viable level of UK activity in the following ways:

- Providing core funding to strengthen UK involvement and sustain UK leadership in astroparticle physics experiments and projects (focusing on astrophysics with energetic particles, and fundamental physics with particles of astrophysical origin), and thus retaining university and industrial expertise and capability in technologies and techniques for projects (eg optoelectronics, fast electronics and low-background sensors).
- Providing a focus for the community and a forum for the discussion of strategy, including the future for astroparticle physics experiments at the Boulby facility. It is recognised that, particularly in the current financial climate, a consolidation of UK astroparticle physics effort in a smaller number of projects is necessary and a Virtual Institute is considered to be an effective way of achieving this. The Virtual Institute would actively engage the astroparticle physics community in seeking out new scientific opportunities.
- Supporting astroparticle physics theory and collaboration between theorists and experimentalists, with the aim of improving the discovery and study potential of future instruments and enhancing the UK impact in the scientific exploitation of those instruments. It is proposed that the Virtual Institute should provide support for staff and PDRA time, engineering expertise, prototyping of hardware and travel, and also hold regular meetings and scientific workshops. At least part of the Virtual Institute budget should be allocated dynamically to increase flexibility and to allow rapid response to new opportunities. Theoretical activities would be included at the 10% level, significantly strengthening the existing links between theory and experiment as well as generating new links between theorists in different areas of astroparticle physics.

9. The level of activity that could be achieved under different funding scenarios over the next three years is outlined below:

- £0.5 million a year—maintain a minimum level of involvement (but eroding UK leadership roles) in perhaps two projects, which will sustain some capability in core astroparticle physics disciplines in the UK.
- £1 million a year—sustain leadership roles in the design phases of major particle astrophysics projects, including essential exploitation of existing instruments.
- £2 million a year—as above but also allow considerable prototyping of instrumentation, increased engagement of UK industry, enabling a major UK contribution to the construction phases of future astroparticle physics projects.

10. Reaching a funding level of £2 million a year by around 2014 would provide for capital investment in the construction of at least one next-generation astroparticle physics project (eg CTA, LUX-ZEPLIN and/or EURECA), ensuring leadership roles that are sustainable into the exploitation phases.

11. The astroparticle physics community is awaiting a response to the proposal for a Virtual Institute from the STFC, which is expected within the next week or so.

The Institute of Physics

16 March 2011

iii) References

[1] http://www.stfc.ac.uk/resources/pdf/DP2011–15.pdf

[2] http://press.web.cern.ch/press/PressReleases/Releases2010/PR18.10E.html. The UK subscription to CERN is approximately 20% and will reduce by approximately 27m CHF (£18 million) over the five year period.

[3] http://cdsweb.cern.ch/record/680242

[4] http://cerncourier.com/cws/article/cern/42092

[5] http://www.iop.org/publications/iop/2009/page_38211.html

Written evidence submitted by Science and Technology Facilities Council (STFC) (APP 33)

Background

1. The Science and Technology Facilities Council (STFC) is an independent, non-departmental public body of the Department for Business, Innovation and Skills (BIS) and is one of the UK's seven research councils.[9] STFC makes it possible for a broad range of scientists to do the highest quality research tackling some of the most fundamental scientific questions.

2. This submission does not include or necessarily reflect the views of the Science and Research Group in the Department for Business, Innovation and Skills.

Q1. *The impact of reduced capital funding on UK capability*

3. STFC carried out a thorough prioritisation of its programme in 2009 which focused support on its highest priority activities. This forms the basis of the STFC's Delivery Plan for the next four years[10] alongside our Corporate Strategy.[11] STFC has welcomed its CSR settlement and recognises the Government's strong support for science and technology.

4. STFC is heavily dependent on capital. A large proportion of our capital budget in the last Spending Review period was spent on maintaining and developing facilities that support the UK research base; very little was spent replacing old infrastructure. With the other research councils, STFC has stressed the requirement for sufficient operating capital to make the running of these facilities fully sustainable. The capital allocation for the UK facilities in CSR 2010 addresses this need. STFC has worked closely with BIS to re-evaluate its capital needs, reassessing priorities, identifying funds to sustain its world leading facilities and the changing requirements of the international subscriptions to European Organization for Nuclear Research (CERN) and European Southern Observatory (ESO). The rebalancing between capital and resource funding in its allocation reflects the changing profile of those requirements over time.

5. Nevertheless, the reduced capital available will potentially have impacts on programmes such as accelerator research and development, the Muon Ionisation Cooling Experiment (MICE) at Rutherford Appleton Laboratory, and funding for equipment within University grants. In all these areas capital spending will have to be reduced based on the current funding allocation.

Q2. *The impact of withdrawal from international ground-based facilities on the UK's research base and international reputation*

6. STFC's Delivery Plan details the UK's commitment to facilities in the UK and across the globe, eg commitments to CERN, Institut Laue Langevin (ILL) and European Synchrotron Radiation Facility (ESRF) in mainland Europe; and investments further afield, such as ESO telescopes in Chile, as well as closer to home, such as ISIS, the Diamond Light Source and the Central Laser Facility in the UK.

7. STFC is grateful, on behalf of its science communities, that CSR2010 did not mean that the UK had to withdraw support for any of these commitments.

8. With regard to astronomy, early in the last decade the UK astronomy community decided to join ESO in order to benefit from shared developments with its European research community colleagues. In particular, the priorities focused on the new facilities being built in Chile, including Atacama Large Millimeter/submillimeter Array (ALMA) and the UK's investment in the Visible and Infrared Survey Telescope for Astronomy (VISTA) telescope, but also leading on to UK participation in the next generation of giant optical telescopes, which have most notably included the European Extremely Large Telescope (E-ELT).[12]

9. The cost of the UK's accession to ESO was found partly from savings resulting from phased withdrawal from existing ground based telescopes on La Palma and Hawaii and in Australia, and partly by additional government funding. Ongoing commitments to high priority science programmes and to international partners meant that withdrawal took a decade to achieve. STFC withdrew from the Anglo-Australian Observatory in 2010 and currently foresees withdrawal from the Hawaii and La Palma telescopes within the current CSR period.

10. Throughout these processes, STFC and its predecessor Councils communicated the plans clearly to all of the UK's international partners and maintained an open dialogue.

11. Within the current CSR period, STFC's priorities in ground-based astronomy were re-addressed through a dedicated independent ground-based astronomy review panel, commissioned by STFC in 2009 and chaired

[9] The seven research councils are: Arts and Humanities Research Council (AHRC); Biotechnology and Biological Sciences Research Council (BBSRC); Engineering and Physical Sciences Research Council (EPSRC); Economic and Social Research Council (ESRC); Medical Research Council (MRC); Natural Environment Research Council (NERC); Science and Technology Facilities Council (STFC). Research Councils UK (RCUK) is a strategic partnership established in 2002 to enable the councils to work together more effectively to enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the delivery of the Government's objectives for science and innovation.

[10] http://www.stfc.ac.uk/About%20STFC/20594.aspx

[11] http://www.stfc.ac.uk/About%20STFC/288.aspx

[12] http://www.eso.org/public/teles-instr/e-elt.html

by Professor Michael Rowan-Robinson.[13] This panel carried out a detailed community consultation. Advice was sought from STFC's standing science advisory panels, which include practising UK astronomers. The peer reviewed advice gave a higher scientific priority to STFC exploiting its investment in the ESO than to STFC's older investments in Hawaii and the Canary Islands. This confirmed the previously agreed position.

12. The research community has made it clear to STFC that there is still scope to undertake excellent optical and infrared wavelength science research in the Northern hemisphere. Furthermore, the Northern hemisphere facilities offer good opportunities for student training and as a testbed for technology. In the light of this, STFC has been able to extend support for its UK Infrared Telescope in Hawaii through 2013 by making significant economies in its mode of operation. We have also confirmed a limited extension to support for the James Clerk Maxwell Telescope (JCMT)[14] in Hawaii in order to exploit a new instrument. For these telescopes and our facilities in the Canaries we are discussing future management arrangements with potential new partners which may include access to some, if not all, of these facilities.

13. As with all supported disciplines, STFC's and its science committees have to consider the case for, and balance of, UK investment in astronomy facilities in competition with other demands on the STFC's overall science programme budget.

Q3. *Whether the Science and Technology Facilities Council has sufficiently engaged with its research community in these two areas on its strategic direction and impact on budget reductions*

14. During the prioritisation of its programme in 2009[15] and in preparing and developing its submission to BIS for the Spending Review, STFC worked closely with its research community, as indeed we endeavour to do at all times.

15. STFC's engagement with the disciplines we support most importantly includes the operation of our Science Board which advises on all aspects of STFC's science and technology programme,[16] supported by its science committees—the Particle Physics, Astronomy and Nuclear Physics Science committee (PPAN); and the Physical and Life Sciences committee (PALS). These work in close collaboration with their respective advisory panels.

16. However, in addition, during the period of CSR2010, STFC's Council deemed it important to establish a CSR Working Group which met regularly and worked intensively with the STFC Executive.[17] The Working Group comprised Professor Keith Burnett (Chair of the Working Group, VC Sheffield University), Professor Martin Barstow (pro-VC Leicester University), Professor Sir Peter Knight FRS (Imperial College), Dr Philip Kaziewicz and Mr Marshall Davies.[18]

17. At all times during the CSR process, the Working Group provided oversight on the strategic impact of the potential CSR settlement on the research community and the breadth of the STFC's science programme. Under certain planning scenarios, CSR2010 could have had very much greater impact on parts of the science programme than resulted from the final allocation. The operation of this advisory body of STFC Council was integral to providing appropriate engagement with the research community with regard to CSR2010's strategic and local impacts.

18. STFC holds regular meetings and consultations with learned societies such as the Institute of Physics (IoP), and the Royal Astronomical Society (RAS), and regular town hall meetings with the particle physics, nuclear physics and astronomy communities. STFC consults closely with its international partners, CERN, ESRF, ESO, ILL, universities, Diamond, and other research councils.

19. STFC has made a clear commitment in its Delivery Plan to further embed and develop these relationships.

Q4. *Opportunities for, and threats to, outreach and inspiring the next generation of astronomers and particle physicists*

20. STFC has always recognised that the research science it supports plays a key role in inspiring future generations across the STEM disciplines. STFC's Public Engagement strategy: *"Inspire and Involve"* is based on the inspirational science, technology, and engineering in our programme.

21. Around 90% of physics undergraduates mention science within the STFC portfolio as topics that drew them to their studies.

22. In our Delivery Plan, STFC has confirmed the commitment that we made in 2009 to sustaining support for public outreach and science communication, and indeed to expanding our work in these areas.

23. STFC's methods of engagement primarily involve funding projects and personal fellowships, particularly supporting researchers via facilitation and training to inspire and enthuse new generations about science,

[13] http://www.stfc.ac.uk/6019.aspx
[14] http://www.jach.hawaii.edu/JCMT/
[15] http://www.stfc.ac.uk/News%20and%20Events/13710.aspx
[16] http://www.stfc.ac.uk/About%20STFC/158.aspx
[17] http://www.stfc.ac.uk/About+STFC/306.aspx
[18] http://www.stfc.ac.uk/About%20STFC/132.aspx

encourage them to continue study in science, technology, engineering and mathematics (STEM) subjects, and to improve public understanding of scientific advances. STFC research grant application forms all include a request for an "impact plan", which is intended to encourage thought and initiate the exploration of possible routes of engagement by the applying groups, and this is used as a proposal assessment criterion.

24. STFC's outreach programme[19] includes: stimulating and responding to public interest in research developments (including via the mass media, new and social media); linking young people and schools with STFC science and technology; supporting researchers; and capitalising on STFC Laboratories and Campuses at Harwell and Daresbury, as excellent technical sites for regional STEM and skills activities.

25. In encouraging researchers in these ways we are implementing and hope to encourage the national and international engagement in science, including the Public Engagement Concordat.[20] STFC works with RCUK in the collective research councils' public engagement programmes,[21] whilst maintaining a distinctive STFC-led programme focused on our research areas. STFC works in partnership with the UK Space Agency.[22] given the thematic closeness of astronomy and space science.

26. Recently, the BIS Expert Group Report on *Science and Trust*[23] and the President of the Royal Society (Sir Paul Nurse),[24] have argued that increased public engagement is an important element of gaining public trust. STFC appreciates the importance of public confidence in science. STFC's science areas often provide suitable topics to engage citizens with the process of science and the people who do it.

27. In linking research projects with public and schools, we emphasise the UK's role and UK people in the given project. Our public education funding schemes, personal fellowships, training and facilitation aim to help researchers inspire and enthuse young people and encourage them to continue to study STEM subjects.

28. With regard to the National Schools Observatory, in which we are aware the Committee has a close interest, STFC has supported this and many other projects through our Science in Society grants schemes,[25] and also "in kind" through co-operation and support. The distinctive astronomy outreach offer to UK schools through the existence of robotic telescopes (such as the Faulkes Telescopes,[26] the Liverpool Telescope[27] used by the National Schools' Observatory[28] and the Bradford Robotic Telescope)[29] compete for STFC's public engagement funding through an open and competitive peer review process. STFC has supported all three of these initiatives through its public engagement funding schemes.

29. Aside from grant funding for the La Palma telescope in its early stages (for use as a research tool), STFC has had no operational involvement in the day to day running of these telescopes. Their continued operation is the responsibility of their respective owners and partners. However, we wholeheartedly support their outstanding work in public education in schools and beyond and we continue to encourage and welcome bids for financial support for their work through our Science in Society funding programmes.

30. Overall, STFC makes investments in public engagement activities through our portfolio of schemes and activities to make the greatest impact, whilst retaining a strategic overview. This strategic overview includes a mandate that we are primarily a research body. At all times we refer to our Royal Charter obligations:

- To promote and support high-quality scientific and engineering research by developing and providing, by any means, facilities and technical expertise in support of basic, strategic and applied research programmes funded by persons established in Our United Kingdom and elsewhere.
- To promote and support, by any means, high-quality basic, strategic and applied research and related post-graduate training in astronomy, particle physics, space science and nuclear physics and research in any other field which makes use of scientific facilities where access is provided, arranged or otherwise made available by the Council, having regard to the objects of the other research councils.
- To promote and support the advancement of knowledge and technology (including the promotion and support of the exploitation of research outcomes) and to provide trained scientists and engineers, and thereby to contribute to the economic competitiveness of Our United Kingdom and the quality of life of its people, meeting the needs of users and beneficiaries.
- In relation to the activities as engaged in by the Council above and in such manner as the Council may see fit:
  - to generate public awareness;
  - to communicate research outcomes;
  - to encourage public engagement and dialogue;

[19] http://www.stfc.ac.uk/Public%20and%20Schools/2625.aspx
[20] http://www.publicengagement.ac.uk/why-does-it-matter/concordat
[21] E.g. http://www.rcuk.ac.uk/per/Pages/Beacons.aspx
[22] http://www.ukspaceagency.bis.gov.uk/default.aspx
[23] http://interactive.bis.gov.uk/scienceandsociety/site/trust/files/2010/03/BIS-R9201-URN10–699-WEB.pdf
[24] http://royalsociety.org/news/paul-nurse-presents-horizon/
[25] http://www.stfc.ac.uk/Public%20and%20Schools/1344.aspx
[26] http://www.faulkes-telescope.com/
[27] http://telescope.livjm.ac.uk/
[28] http://www.schoolsobservatory.org.uk/
[29] http://www.telescope.org/

— to disseminate knowledge; and

— to provide advice.

STFC and the House of Commons Science and Technology Select Committee

31. STFC welcomes the Committee's continued interest in STFC's mission, vision[30] and operation. We look forward to continuing to contribute to the valuable work the Committee undertakes in supporting the UK's research base, the science community and the international context in which we operate.

Science and Technology Facilities Council

16 February 2011

Supplementary written evidence submitted by Science and Technology Facilities Council (STFC) (APP 33a)

Memorandum from STFC in Response to Questions from the House of Commons Science and Technology Committee

1. The table below gives details of spending on each of the themes, Astronomy, Particle Physics, Particle Astrophysics and Nuclear Physics for each of the next four years including a breakdown by capital and resource and a comparison with 2010–11.

Delivery Plan (£M)— Resource and Capital	*10–11*		*11–12*		*12–13*		*13–14*		*14–15*	
	Res	*Cap*	*Res*	*Cap*	*Res*	*Cap*	*Res*	*Cap*	*Res*	*Cap*
Astronomy										
Subs (ESO)	10.9	18.3	11.57	17.78	11.69	7.17	11.56	7.37	11.50	7.57
Development	3.21	1.9	5.04	2	7.35	2	8.84	2	9.76	2
Ops/exploitation	46.2	4.4	45.44	0.50	37.88	0.50	33.15	0.50	32.45	0.50
Studentships/Fellowships	14.95	0	15.25	0	15.09	0	14.91	0	15.22	0
Particle physics										
Subs (CERN)	63.6	32.9	81.81	21.60	89.36	15.39	90.45	15.29	92.43	15.15
Development	8.5	2.6	11.12	2.4	11.44	2.4	12.97	2.4	14.15	2.4
Ops/exploitation	35	5.5	30.5	0.5	30.56	0.5	30.87	0.5	31.84	0.5
Studentships/Fellowships	9.6	0	9.8	0	9.7	0	9.59	0	9.79	0
Nuclear physics										
Subs	0	0	0	0	0	0	0	0	0	0
Development	2.5	0	1.69	0	1.53	0	1.68	0	1.89	0
Ops/exploitation	6.22	0.1	3.53	0.2	3.18	0	4.83	0	5.3	0
Studentships/Fellowships	1.07	0	1.09	0	1.08	0	1.07	0	1.09	0
Particle astrophysics										
Subs	0	0	0	0	0	0	0	0	0	0
Development	0.2	0	0	0	0	0	0	0	0	0
Ops/exploitation	2.3	0.7	2.97	0	2.74	0	2.62	0	2.69	0
Studentships/Fellowships	1.07	0	1.09	0	1.08	0	1.07	0	1.09	0

Notes:

2011–12 Capital for ESO includes the final capital special payment relating to accession to ESO

Capital for operations /exploitation lines divided between Astronomy, Particle Physics and Nuclear Physics on a pro rata basis—and therefore included for indicative purposes only

The Astronomy figures have changed since the indicative submission to the Committee in January

Please find the below figures for STFC's capital spend forecast in the financial year 2010–11. Like Appendix C in the STFC Delivery Plan, these figures do not include Administration.

[30] http://www.stfc.ac.uk/About%20STFC/10713.aspx

	2010–11
	£m
International subscriptions	63.7
Facilities	13.5
Core Programme	14.5
Diamond I & II	9.6
Diamond III	0.0
Grants to HEIs	2.7*
Total	104.0

**based on provisional figures from Science Programmes Office (SPO) Exploitation Grants.*

February/March 2011

Further supplementary written evidence submitted by Science and Technology Facilities Council (STFC) (APP 33b)

PPA(02)01
2–3 February 2002

PARTICLE PHYSICS AND ASTRONOMY RESEARCH COUNCIL

MINUTES OF THE 38th COUNCIL MEETING HELD ON 5 DECEMBER 2001

Present:	Mr Peter Warry CEng, FIEE, FIMechE, FCMA	Chairman
	Professor Ian Halliday FRSE	Chief Executive
	Mr Robert Barnett OBE	
	Professor George Efstathiou FRS	
	Professor Brian Foster FInstP	
	Professor Andy Lawrence FRSE	
	Professor Dewi Lewis FInstP	
	Professor Keith Mason	
	Ms Judith Scott CEng, FBCS	
	Mr David Steeds MA, FCA	
Secretary:	Mr Jim Sadlier	Director Strategic Planning and Communications
By Invitation:	Dr Frances Saunders FInstP	OST
	Professor James Stirling FRS	Chairman, Science Committee
	Professor Martin Ward	Deputy Chairman, Science Committee
PPARC Staff:	Mr Jeff Down	Head of Finance
	Mr John Love	Director Administration
	Professor Richard Wade	Director Programmes
	Mr Jim Gallagher	

CHAIRMAN'S INTRODUCTION AND ATTENDANCE

1. The Chairman introduced himself to Council, noting his high regard for PPARC's exciting and well-defined area of science. He acknowledged the world-class status of the scientific programme, and how privileged it was to be involved with Council in steering and formulating its future scientific policy.

2. Apologies for absence were received from Mrs Mandy Mayer (DTI); Professor Ian Ritchie; Professor John Pendry (ICSTM); and Professor Chris Sachrajda (Southampton).

ITEM 1 MINUTES OF THE 37TH MEETING PPA(01)41

3. The minutes were approved as a correct record of the previous meeting. The following matters arising were reported.

Matters Arising From Minutes

Minute 15—The UK Dark Matter Programme

4. Mr Sadlier reported that plans to promote the official opening of the UK Dark Matter project had been postponed to allow for major construction work at the Boulby site. The campaign would be rescheduled to coincide with the public launch, scheduled for the summer 2002.

Minute 16—The Sunday Times Astronomy CD-ROM

5. Mr Love informed Council that public demand for the second free astronomy CD-ROM from The Sunday Times, had been high at around 50,000 responses. Unfortunately distribution had been delayed because of a temporary production problem. Copies would be circulated to members as soon as available.

Minute 24—VISTA

6. Professor Wade confirmed that VISTA had successfully completed its Phase A design review by the end of October. He noted that the project specification (which includes an infrared camera), had not been altered in respect to potential overlap with NASA's proposed PRIME space mission. A review of the management structure had resulted in responsibility being transferred entirely to PPARC's Astronomy Technology Centre, with a VISTA Management Committee (chaired by Professor Wade) to oversee the project.

ITEM 2 CHIEF EXECUTIVE'S REPORT PPA(01)42

QQR

7. Professor Halliday reported that Stage Two of the Quinquennial Review had been finalised by OST and would in due course be circulated to Council. He noted that the Report had endorsed the creation of a Research Councils Strategy Group (RCSG), and that little else had changed from the earlier draft. The RCSG would take a high level view on funding large, long-term projects and provide further emphasis on cross-council activities.

ESA Ministerial

8. Professor Halliday reported on the recent ESA Ministerial meeting decision which set the members core programme contribution at €369 ECU for this and next year. Council noted that this was below what ESA required to cover its current programme and, despite an additional 2.5% increase built in from 2003, represented a cut in cash terms. Because the last Spending Review had failed to provide any additional uplift for the space programme, the UK had hoped for zero indexation. Professor Ward added that the extra 2.5% was likely to be interpreted differently by ESA and its member states, the former seeing this as a non-inflationary increase. Professor Halliday noted that ESA must review its programme to identify savings within this cash limited environment.

DTI Review

9. Professor Halliday reported that the DTI Review, now underway, would place heavy demands on Dr Taylor (OST). As a result, he may have to drop some of his current commitments, such as the Gemini South opening ceremony in March 2002.

House of Commons Science and Technology Select Committee Reviews

10. Professor Halliday noted that Patricia Hewitt (Minister for Trade and Industry) had been invited to give evidence to the Select Committee, and that it was highly likely these reviews would encompass large facilities.

SR Delay

11. Mr Sadlier reported that the SR2002 was likely to offer more freedom for the science programme, by providing a general uplift (although specific themes could be expected as well). Dr Saunders confirmed that negotiations were on-going with Treasury, but warned that Treasury had always exhibited a preference for explicitly focused and measurable areas. Professor Halliday noted that the proposed RCSG may have a strong role in defining the split on SR2002 funding—and that this would not guarantee every Research Council a general or equal uplift.

12. The Council noted the Chief Executive's Report.

ITEM 3 CERN FUNDING AND MANAGEMENT PPA(01)43

13. Professor Halliday recapped on the main points of the CERN funding situation, as raised at the previous Council meeting (approved minutes, paragraph 11). He outlined the action taken by the Executive to fore fill these criteria and reported on the current stance taken by the main factions at CERN Council and that of its management.

14. He had persistently requested that CERN provide an analysis of the damage to scientific research, for each of the options proposed to deal with the overspend. It was apparent that broader options to cut various experiments were being ignored on the basis that annual membership contributions would offset such pressures.

15. The Council of CERN had accepted the need for an External Review Committee (ERC) on finance, and this would be chaired by the eminent Dr Robert Aymar (Director, ITER). However, there was concern over the bottom-up process adopted in its draft terms of reference (tabled). Council expressed a preference to clarify the overall position rather than lose focus on the detailed bookkeeping. It regarded the Easter deadline for the ERC to report back to CERN Council as far to lengthy.

16. Professor Halliday noted that a stage two review would deal specifically with the CERN management structure. He added that he was aware of five review committees on various internal affairs, asked to identify an overall cost reduction of 5%—instead of considering options to cut the programme. Professor Lewis reported that he had been asked to participate in one of the internal review committees and that he too was concerned at the direction implied by its terms of reference. His experience indicated that this approach was not likely to shed much light on the key factors that created the current crisis at CERN.

17. Professor Halliday regarded Easter as a critical time for CERN in respect to delivery of a workable recovery package. Should this fail to happen PPARC would insist that it was time to change CERN's senior management.

18. With respect to on-going work for LHC, Professor Halliday reported that he had asked Dr Mianni if CERN had sufficient funds to cover the large dipole contracts. He advised him to consider delaying the dipole delivery rather than ignoring the financial liability risk factor to member states. He advised Council that if CERN proceeded regardless of a clearer understanding of the current financial crisis, then the UK would have no choice but to refuse approval of the budget for FY 2002–03. He regarded it as highly likely that there would be attempts to charge the overspend on top of the normal membership contribution, and wished to avoid this high risk. He did however say that it was unclear whether CERN could place the contracts regardless of an approved budget.

19. Professor Lewis (Chairman, Audit Committee) endorsed the PPARC stand. He noted that the Audit Committee had failed to comprehend how CERN handled the budget for the LHC. He however, also noted concern for the PPARC management information available, stating that it was geared more towards recording issues rather than providing a sufficient model to manage potential risk to the programme.

20. Mr Steeds reported that he, along with professors Foster, Lawrence and Mason, had visited CERN shortly after the September Council meeting. CERN management had implied that PPARC must have known about an overspend because there had been no contingency in the budget. Professor Halliday highlighted the American review of the LHC project, which had been assured by CERN that contingencies had been allowed for. CERN's recent attitude to this had been that in reality no such allowance had existed, because the project would never have been approved if added. CERN management regarded the overspend as negligible when compared with other international facility projects of this scope.

21. Professor Foster asked Council to temper its deliberations and acknowledge the proven expertise at CERN, which was capable of delivering such leading edge physics. It was important to help repair the management structure so that the project demands can best be met.

22. Dr Saunders proposed that Council mandate the PPARC Executive to approve the CERN budget only if it was based on a sensible finance plan. She suggested lobbying other partner countries with similar concerns at the lack of a top-down finance review. Mr Steeds also advised that the UK (PPARC) be seen to ally itself to other partner countries when confronting CERN management.

23. Council noted the significant cost overrun identified for the LHC project and noted the actions taken to date to handle the situation.

ITEM 4 UK ACCESSION TO ESO PPA(01)44

24. Professor Halliday introduced the case for accession to the European Southern Observatory (ESO). He reported on the steps leading to the current proposal, how both Dr Taylor (OST) and Lord Sainsbury (Minister for Science) had accepted that this was the next big step for UK astronomy; the various internal and external reviews endorsing this process and the communities demand for 8 Metre and larger facilities in the next generation of world class astronomy. The ESO deal would provide access to 20% of four 8M telescope suites and participation on ALMA in exchange for in kind payments by way of access to the VISTA telescope and UKIRT's Wide Field Infrared Camera (WF-CAM), and cash based investment over the next ten years. The community had endorsed this package by accepting re-structuring of its existing ground based facilities and savings in the order of £5 million to free funds in its support.

25. He informed Council that ESO Council had approved the conditions of UK membership at its meeting earlier this week. If PPARC Council approved the package it would set in motion a series of parliamentary procedure over the next six months, leading to the formal inter-governmental agreement.

26. Professor Wade reiterated the lengthy discussions between him, the site directors and partners in agreeing to changes to their science output, and allowing for the clean departure from facilities—avoiding potential

severe frictional costs to PPARC. He acknowledged that these efforts would provide the savings required to optimise the ESO offer. Professor Mason congratulated the Director, Science in delivering such an ideal package.

27. He noted that the E-Merlin running costs of £2 million had been built into the new structure, hence providing the UK with a world class radio astronomical facility. The E-Merlin package had been dependant on a firm commitment from PPARC before Christmas or the offer of capital would have been dropped.

28. Professor Stirling highlighted the Science Committee's statement of support (Annex 3), which was the fruition of months of discussion and debate that involved access to all the reviews. He and Professor Ward confirmed that the ESO deal represented a tremendous boost to UK astronomy, and was accepted by the community on the basis of the loss of current facilities.

29. Professor Wade noted the pressure on the programme created by the accession to ESO, and confirmed that there was no headroom to further exploit the UK's participation. He highlighted the efforts taken to reduce PPARC's risk, but acknowledged that the impact of early withdrawal from the WHT was €15 million ECU. Worse case scenarios were built-in in respect to restructuring costs and the gradual reduction of staff over five years (ie planned and early losses).

30. Mr Down confirmed that he was satisfied with the level of consultation between him and the Director Science. He accepted that there were individual areas where assumptions were open to interpretation, but he believed that the overall package was at an acceptable level of risk and achievable. He confirmed that a financial expert had not produced the finance model.

31. Council discussed the various risk factors to PPARC, such as the cost of VISTA, and agreed that a mechanism must be created to measure performance against the agreed criteria and monitor our status within the approved package. It was agreed that such information be incorporated within the annual Operating Plan/ Report.

32. Council agreed to the proposed conditions for UK membership of ESO.

ITEM 5 OPERATING PLAN 2002 PPA(01)45

33. Professor Wade presented the plans to produce the Operating Plan for the three year period 2002–03 to 2004–05. The Science Committee had been involved in reviewing the programme for the next 10 years, based on assumptions of the resources likely to be available. It had recognised the severity to cash spend caused by re-structuring in the initial years but regarded this as sustainable.

34. The planning assumptions anticipated some compensation for indexation, and recognised that if this was not so, then there would be a need to recognise that the programme was overheating and must seek a balance on commitments. Professor Stirling endorsed this view, referring to the last Particle Physics Committee's commitment to building in headroom to exploit participation in the Large Hadron Collider (LHC). Particle physics faced an accumulated £12 million deficit by 2004. The Science Committee had recently created a sub-panel under Dr Thomas, to discuss restructuring its programme using the same mechanism used for the Ground-Based programme. The Panel had already met three times and would provide its draft report in January. Professor Foster warned that the implications of its recommendations was likely to impact on our relationship with existing partners, and at very least disturb our reputation as a reliable partner.

35. A draft of the Operating Plan would be presented at the next Council meeting, outlining the strategy adopted. It would be to early to include actual figures, but this information would be provided in correspondence prior to submission to OST at the end of March 2002.

36. The Chairman noted the plans to produce the Operating Plan and the difficulties facing the particle physics community. He suggested that these issues be considered as part of the Strategy Weekend meeting in February 2002.

ITEM 6 PLANS FOR STRATEGY MEETING 2002 PPA(01)46

37. Mr Sadlier explained that the annual Strategy Weekend provided Council with an opportunity to step away from the formal business and focus on high level issues. He highlighted a few examples of topical issues to consider and asked Council to propose other subjects for discussion.

38. Council proposed topics affecting the community such as the university/PPARC responsibility for infrastructure; defining a meaningful PPARC industry role (perhaps using the linear collider to illustrate it); and setting a strategic policy for space research in relation to the balance between investment and exploitation.

39. Council agreed to forward suggestions to Mr Sadlier within the next few weeks.

ITEM 7 ANY OTHER BUSINESS ORAL

40. Mr Love confirmed that there were plans to provide access to meeting papers for PPARC's respective committees and panels on an "Extra-net" web service. This had already been successfully introduced for the Science Committee and a similar service would be provided for Council meetings.

41. There was no other business discussed by Council.

ITEMS 8–10

42. The Council noted the following papers for information:

43. Draft minutes of the November 2001 audit committee **PPA(01)47**

44. Revised Council membership **PPA(01)48**

45. Circulated material **PPA(01)49**

ITEM 11 DATE OF NEXT MEETING ORAL

46. The next Council meeting will be incorporated within the annual Strategic Weekend on 2 and 3 February 2002, at the Lydiard House Conference Centre, Swindon.

PPA(01)44
5 December 2001

UK ACCESSION TO ESO

Note by Director Programmes

EXECUTIVE SUMMARY

This paper describes the proposed terms of the UK accession to ESO, and the means by which the necessary resources will be found, through a combination of in-kind and cash contributions.

The agreed terms for accession are set out in Annex 1.

Council has previously agreed that an element of the cash contributions should be found from savings through a restructuring of the ground-based astronomy programme. Following a review of each of the ground-based facilities, proposals (at Annex 2) to achieve these savings were presented to the Science Committee on 27/28 November. The Science Committee concluded that, based on the savings now identified, it recommended to Council that the UK should accede to membership of ESO. A statement from the Committee is attached at Annex 3.

Council is invited to:

- **approve the terms of the agreement negotiated with ESO on the "special contribution" comprising cash and in-kind contributions;**
- **approve the proposed restructuring of the ground-based programme, and specifically**
  - **AAT - a phased reduction in PPARC funding of the operation of the Anglo-Australian Telescope to 2006/07, by when the UK's contribution will be capped at £200k p.a. (2006/07 prices). The UK's share of observing time will be reduced from 50% to 7%.**
  - **JCMT - a phased reduction in PPARC funding in JCMT operating costs, through efficiency savings and changes in the operating mode of the telescope. By 2006/07 PPARC's contribution will be £1.7M p.a. (2006/07 prices).**
  - **UKIRT - a phased reduction in PPARC funding in UKIRT operating costs through efficiency savings and changes in the operating mode of the telescope. By 2006/07 PPARC's contribution will be £1.9M p.a. (2006/07 prices).**

- **ING - withdrawal of PPARC funding for the JKT(2002/03) and the INT (2003/04), and a phased reduction in funding for the WHT. The UK's observing time on the WHT will be reduced from 60% to 48%. By 2006/07 PPARC's contribution will be £1.6M p.a.(2006/07 prices).**

- **E-Merlin – PPARC funding of the operating costs of E-Merlin at the level of £2.1M p.a. (2006/07 prices).**

- **note that the above programme represents the first phase in re-shaping PPARC's investment in ground-based astronomy facilities over the next decade. The long-term strategy will see PPARC withdraw from the AAT, JCMT, UKIRT, and the ING by the end of the decade.**

- **agree to proceed to accession to ESO on the basis of the negotiated terms and the achievement of the necessary savings which, together with the additional funds provided by government, provide the means by which PPARC can meet its obligations, as set out in Table 1 attached.**

ESO MEMBERSHIP

1. Council paper PPA(01)34 reported progress on negotiations between PPARC and ESO on the terms of the UK's accession. Further discussion have since taken place and agreement has been reached between the two organisations, subject to the approval of their respective Councils.

2. The detailed terms of accession are contained in an Agreement and an Exchange of Letters, appended at Annex 1. The UK will provide a 'special contribution' representing the UK's share (determined by NNI) in capital investment and fitting-out costs already incurred for VLT. The 'special contribution' has been determined to be 122.862M Euros, of which 71.762M Euros will be paid in cash over the period to 2011 and 51.1M Euros will consist of in-kind contributions. Additionally we will be required to make an annual contribution to the operating costs.

3. The in-kind contributions comprise:

   a. VISTA (Visible and Infrared Survey Telescope), comprising a 4-m class survey telescope with an infrared camera, silver coating plant and spare parts, valued at 46M Euros;

   b. access to the UKIDSS survey of the Wide Field Camera (WFCAM) of the United Kingdom Infrared Telescope (UKIRT) from the date of accession;

   c. an E-Science program, to be defined and controlled by ESO, totaling 5.1M Euros.

4. In exchange, the UK will become a member of ESO with effect from 1 July 2002. The UK will thereafter participate in the ESO programme, including the

ALMA project, as a Member State of ESO, although UK access to the VLT will not commence until April 2003 in recognition of the extended payment schedule for the special contribution.

5. The UK application for membership will be considered by an Extraordinary Meeting of ESO Council on 3 December 2001. The outcome of that meeting will be reported orally to Council.

6. Following approval by ESO and PPARC Councils, the formal agreement will need to be put to Parliament early in 2002. The ESO procedures require that the United Kingdom's instrument of accession be deposited with the Ministry of Foreign Affairs of the French Republic not later than 1 July 2002. PPARC is working closely with OST to complete all the necessary procedures in good time.

7. Council will wish to note that it is hoped that the Summer 2002 ESO Council meeting can be held in the UK to celebrate the UK's accession.

MEETING THE CASH ELEMENT OF THE ESO JOINING FEE

8. To enable the UK to proceed with accession to ESO, it is necessary to demonstrate that the plans for restructuring the ground-based activities provide the headroom necessary to accommodate both the annual subscription and the agreed profile of payments towards the joining fee.

9. To this end, all existing ground-based facilities have been subjected to reviews of the current and possible operating modes and costs. In the cases of MERLIN, ING, JCMT and UKIRT the Directors produced restructuring plans that have been subjected to detailed review with international and independent membership. Where appropriate these plans have been discussed and agreed with our international partners. The 'Background to the Current Strategy for the Ground-Based Programme, attached at Annex 2, gives details of the options for each facility, and a summary of the proposed savings, as presented to the Science Committee at its meeting on 27/28 November. The Science Committee's recommendation to Council is attached at Annex 3.

10. Table 1 gives a top level summary of the potential additional cash requirements imposed by joining ESO and the sources of funding from within the ground-based programme; these are:

- the increase to the PPARC baseline;
- the funds accruing from restructuring the existing ground-based facilities;
- the funds previously built into the programme for participation in ALMA, an activity which is now supported through our membership of ESO.

11. Table 1 demonstrates that the cost of joining ESO is more than compensated by the additional funds and savings made elsewhere in the ground-based programme. In the most unlikely and worst case scenario, whereby we are

obliged to provide inflation protection on all our payments to ESO but where we receive no inflation protection through SR2002 or subsequent spending reviews, there would be a 'deficit' of c£4.5M over the next ten years that would need to be covered by further restructuring in the later years.

ACTION

12. Council is invited to approve the UK's accession to ESO on the terms detailed in the paper, and to approve the restructuring of the ground-based programme as set out in the Executive Summary.

TABLE 1: ESO EXPENDITURE AND PLANNED GROUND-BASED SAVINGS

	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	
ESO 'Capital' *	0	0	2101	6461	6823	6788	6958	7132	7310	7493	50866
ESO Subscription *	6150	12607	12923	13246	13577	13916	14264	14621	14987	15360	131651
TOTAL	**6150**	**12607**	**15024**	**19707**	**20200**	**20704**	**21222**	**21753**	**22297**	**22853**	
New Money	6000	10000	10000	10000	10000	10000	10000	10000	10000	10000	96000
Assumed inflation protection **	0	0	1023	1707	2200	2704	3222	3753	4297	4853	23759
G-Based Restructuring	796	1576	2473	3500	4661	5048	5173	5745	9040	11072	49084
Alma provision in previous OP	2366	2500	3500	3500	3700	4000	5000	4050	2101	2153	32870
TOTAL	**9162**	**14076**	**16996**	**18707**	**20561**	**21752**	**23395**	**23548**	**25438**	**28078**	
Cumulative Balance	3012	4481	6453	5463	5814	6862	9036	10831	13972	19197	

* Assumes inflation at 2.5% p.a.
** Assumed inflation protection through the 2002 SR and subequent SRs (on ESO element)

ANNEX 1 TO
PPA(01)44

DRAFT

AGREEMENT BETWEEN

THE EUROPEAN SOUTHERN OBSERVATORY AND

THE GOVERNMENT OF THE UNITED KINGDOM

OF GREAT BRITAIN AND NORTHERN IRELAND

CONCERNING THE ACCESSION TO THE CONVENTION

OF THE EUROPEAN SOUTHERN OBSERVATORY

AND RELATED TERMS AND CONDITIONS

The European Southern Observatory (hereinafter referred to as "the Organization") established by the Convention signed in Paris on 5 October 1962 (hereinafter referred to as "the Convention"),

And

The Government of the United Kingdom of Great Britain and Northern Ireland (hereinafter referred to as "United Kingdom"),

CONSIDERING that, according to Article XIII.4 of the Convention, a State admitted to the Organization by unanimous vote of the Member States shall become member of the Organization by depositing an instrument of accession with the Ministry of Foreign Affairs of the French Republic,

CONSIDERING that the United Kingdom has applied to become a full member of the Organization and that the Council of ESO has approved the admission of the United Kingdom at its xx meeting of xx, 200x,

CONVINCED that this accession will contribute to the achievement of the objectives set out in the Convention,

HAVING REGARD to Article VII, XIII and XV of the Convention,

HAVE AGREED AS FOLLOWS:

ARTICLE 1

The purpose of this Agreement is to determine the terms and conditions under which the United Kingdom accedes to the Convention.

ARTICLE 2

1. The United Kingdom shall become a member of the Organization and a party to the Convention establishing it.

2. The United Kingdom shall endorse the conditions governing its accession as stated in the present Agreement.

ARTICLE 3

1. In accordance with its Article XIII. 4 the Convention shall become effective for the United Kingdom on the date when the United Kingdom's instrument of accession is deposited with the Ministry of Foreign Affairs of the French Republic. The United Kingdom shall take all necessary steps in order that this occurs not later than July 1, 2002. Should it not be deposited by this date, the terms and conditions of this Agreement may be renegotiated at the request of either party.

2. As from the date of accession, the provisions of the Convention, together with all measures taken by the Council, shall be binding for the United Kingdom and shall be applicable to that State. The United Kingdom shall be placed in the same situation as the other Member States with regard to decisions, rulings, resolutions or any other acts made by the Council or, in delegation therefrom, by any subordinate body, and with regard to any Agreement concluded by the Organization. The United Kingdom shall consequently abide by the principles and policies stemming therefrom, and shall whenever necessary take appropriate measures to ensure their full implementation.

ARTICLE 4

In accordance with Article VIII. 3 of the Convention, the United Kingdom shall make the following special contribution as agreed by the Negotiating Teams of ESO Council and of the United Kingdom Particle Physics and Astronomy Research

Council (PPARC), the latter acting for and on behalf of the United Kingdom Government:

1. The United Kingdom shall make payments to ESO not less and not later than as set out below:

Year:	2004	2005	2006	2007	2008	2009	2010	2011
M Euros:	3.229	9.688	9.688	9.688	9.688	9.688	9.688	10.405

The payments shall be subject to the cost variation applied to the ESO contributions and budget as from 2002.

2. The following in-kind contribution shall be made:

2.1 VISTA (Visible and Infrared Survey Telescope), comprising a 4-m class survey telescope with an infrared camera, silver coating plant and spare parts, valued at 46M Euros shall be delivered for installation at the ESO Paranal Observatory not later than August 2006.

2.2 From the date of the ESO accession of the United Kingdom, ESO shall have access to the survey data of the Wide Field Camera (WFCAM) of the United Kingdom Infrared Telescope (UKIRT). The United Kingdom shall have access to the ESO La Silla Telescopes from October 1, 2002 and to the ESO Very Large Telescope from April 1, 2003.

2.3 The United Kingdom shall carry out an E-Science program defined and controlled by ESO, totalling 5.1M Euros.

2.4 Detailed terms and conditions for the above mentioned in-kind contributions shall be agreed in an exchange of letters between ESO and PPARC.

ARTICLE 5

The present Agreement shall enter into force upon its signature.

Done at xxx on xxx, 2001 in two originals, in the English language, both being equally authentic.

For the European Southern Observatory

For the Government of the United Kingdom

APPENDIX 1 TO
ANNEX 1 TO PPA(01)44

Exchange of letters between the ESO Director General and the PPARC Chief Executive

DG to PPARC:

Sir,
I refer to the Agreement between ESO and the United Kingdom concerning the accession to the ESO Convention and related terms and conditions, and to the preceding negotiations between the ESO and PPARC Teams.

I propose that the following Arrangement concerning VISTA, WFCAM/UKIRT and E-Science be concluded:

1. VISTA

The matter is contained in the Attachment which shall be an integral part of this Arrangement.

2. WFCAM Surveys

As part of the UK accession to ESO, the UK has undertaken to make contributions both in cash and in kind. The in kind contribution is to include VISTA. The UK and ESO have further agreed that in view of the expected delivery date of VISTA, ESO shall have access to the WFCAM UKIDSS Survey in accordance with the following proposal:

1. It is intended that at least 75% of the WFCAM time on UKIRT will be used to conduct public surveys.

2. A copy of the raw survey data will be archived in the ESO archive and will be public to the ESO community at the same time as the UK community.

3. All data products from such public surveys, e.g. co-added images, catalogues, etc, shall become public to the ESO community at the same time as in the UK.

4. The expectation is that the survey will be performed as outlined in the UKIDSS proposal (March 2001). In particular, there will be five parts to this survey:
   the Large Area Survey;
   the Galactic Plane Survey;
   the Galactic Clusters Survey;
   the Deep Extragalactic Survey; and
   the Ultra-Deep Survey.

The UKIDSS Consortium will involve ESO astronomers in the future planning and detailed execution plans, including determination of the field centres for the surveys.

5. This agreement applies only to the surveys detailed above; it does not apply to future surveys or to other WFCAM programmes.

6. The format of the data will be FITS, of a fixed configuration for the entire survey, and the integrity of the data will be the responsibility of the UK.

It is the intention of the UKIDSS Consortium at an appropriate future date to issue an open invitation to the ESO community to join the Consortium and to participate in the execution of the surveys described above.

3. E-Science

Since the initial meeting of the UK In Kind Working Group on 15 January 2001, discussions have been held between Peter Quinn, Andy Lawrence, Jim Emerson, members of UK software groups, ESO DMD staff and other ESO members of the UK In Kind WG on the topic of possible contributions in the area of E-Science. Specific discussions of the topic at the WG meetings on 15 January, 5 February and 30 March indicated strong support from both ESO and the UK to identify approximately 5.1M Euros of E-Science programs. These discussions were summarised in the final report of the working delivered to the Negotiation Teams on the UK on UK Accession to ESO on 4 May 2001.

At the meeting of the Negotiating Teams held on 1 October 2001, it was agreed that the UK will carry out an E-Science program defined by ESO with a value if 5.1M Euro. The details of this programme were discussed and agreed at a PPARC-ESO meeting held on 7 and 8 November, 2001.

The programme will be defined in more detail within a specific document defined by ESO and based upon the general framework of a programme costing 10 million DM in total, with the expectation to deliver the programme over a period of 5 years from the date of accession of the UK.

Within the total 10M DM programme, 1-2M DM will be the VISTA DFS deliverables, defined and agreed as deliverables of the VISTA project to ESO [Note: this does not include VISTA data products]. This element will be accounted and valued as part of the e-science contribution, but will be managed as a deliverable within the VISTA project, separately from the programme outlined below.

- ESO will have total responsibility for the programme in respect of project definition, schedule and deliverables

- ESO will decide the suitability or otherwise of an individual for a given project. In making its decision, ESO will adopt the best solution for the project overall.

- ESO will use its best efforts to maximise the use of existing PPARC-supported staff, including where appropriate the use of internal flexibility and utilisation of PPARC-provided effort to substitute for transfers from other areas of ESO programme. ESO will work with PPARC to identify absent skills and adjust the schedule to allow re-training where possible.

- Should there be no suitable individuals available at a given time, new staff will have to be recruited. ESO will define the profile of these new staff, who will be jointly selected by ESO and PPARC. In accordance with normal PPARC practice, all recruitments will be advertised across Europe and will be carried out in accordance with EU and equal opportunities legislation.

- A consideration by ESO in the acceptance of staff will be their ability and willingness to spend periods of time in Garching. Typically, the period will be not less than six months and may be up to the full duration of the in-kind agreement, depending on the nature of the programme.

- There will be a single point of contact on the UK side to handle all manpower acquisition tasks.

- The expectation is that the average cost of a UK staff member will be broadly similar to the average cost of an ESO staff member. Newly-acquired staff will be costed at market value.

If PPARC agrees to the proposals contained in paragraphs 1 - 3 above, this letter and your letter in reply expressing PPARC's agreement shall constitute an Arrangement between ESO and PPARC, which shall enter into force on the date of your letter in reply.

Yours sincerely,
C. Cesarsky

PPARC to DG

Madam,
I confirm receipt of your letter of ..... proposing the conclusion of an Arrangement between ESO and PPARC. Your letter reads as follows:

"I refer to the Agreement between ESO and the United Kingdom concerning the accession to the ESO Convention and related terms and conditions, and to the preceding negotiations between the ESO and PPARC Teams.

I propose that the following Arrangement concerning VISTA, WFCAM/UKIRT and E-Science be concluded:

1. VISTA

The matter is contained in the Attachment which shall be an integral part of this Arrangement.

2. WFCAM Surveys

As part of the UK accession to ESO, the UK has undertaken to make contributions both in cash and in kind. The in kind contribution is to include VISTA. The UK and ESO have further agreed that in view of the expected delivery date of VISTA, ESO shall have access to the WFCAM UKIDSS Survey in accordance with the following proposal:

1. It is intended that at least 75% of the WFCAM time on UKIRT will be used to conduct public surveys.

2. A copy of the raw survey data will be archived in the ESO archive and will be public to the ESO community at the same time as the UK community.

3. All data products from such public surveys, e.g. co-added images, catalogues, etc, shall become public to the ESO community at the same time as in the UK.

4. The expectation is that the survey will be performed as outlined in the UKIDSS proposal (March 2001). In particular, there will be five parts to this survey:
   - the Large Area Survey;
   - the Galactic Plane Survey;
   - the Galactic Clusters Survey;
   - the Deep Extragalactic Survey; and
   - the Ultra-Deep Survey.

   The UKIDSS Consortium will involve ESO astronomers in the future planning and detailed execution plans, including determination of the field centres for the surveys.

5. This agreement applies only to the surveys detailed above; it does not apply to future surveys or to other WFCAM programmes.

6. The format of the data will be FITS, of a fixed configuration for the entire survey, and the integrity of the data will be the responsibility of the UK.

It is the intention of the UKIDSS Consortium at an appropriate future date to issue an open invitation to the ESO community to join the Consortium and to participate in the execution of the surveys described above.

3. E-Science

Since the initial meeting of the UK In Kind Working Group on 15 January 2001, discussions have been held between Peter Quinn, Andy Lawrence, Jim Emerson, members of UK software groups, ESO DMD staff and other ESO members of the UK In Kind WG on the topic of possible contributions in the area of E-Science. Specific discussions of the topic at the WG meetings on 15 January, 5 February and 30 March indicated strong support from both ESO and the UK to identify approximately 5.1M Euros of E-Science programs. These discussions were summarised in the final report of the working delivered to the Negotiation Teams on the UK on UK Accession to ESO on 4 May 2001.

At the meeting of the Negotiating Teams held on 1 October 2001, it was agreed that the UK will carry out an E-Science program defined by ESO with a value if 5.1M Euro. The details of this programme were discussed and agreed at a PPARC-ESO meeting held on 7 and 8 November, 2001.

The programme will be defined in more detail within a specific document defined by ESO and based upon the general framework of a programme costing 10 million DM in total, with the expectation to deliver the programme over a period of 5 years from the date of accession of the UK.

Within the total 10M DM programme, 1-2M DM will be the VISTA DFS deliverables, defined and agreed as deliverables of the VISTA project to ESO [Note: this does not include VISTA data products]. This element will be accounted and valued as part of the e-science contribution, but will be managed as a deliverable within the VISTA project, separately from the programme outlined below.

- ESO will have total responsibility for the programme in respect of project definition, schedule and deliverables

- ESO will decide the suitability or otherwise of an individual for a given project. In making its decision, ESO will adopt the best solution for the project overall.

- ESO will use its best efforts to maximise the use of existing PPARC-supported staff, including where appropriate the use of internal flexibility and utilisation of PPARC-provided effort to substitute for transfers from

other areas of ESO programme. ESO will work with PPARC to identify absent skills and adjust the schedule to allow re-training where possible.

- Should there be no suitable individuals available at a given time, new staff will have to be recruited. ESO will define the profile of these new staff, who will be jointly selected by ESO and PPARC. In accordance with normal PPARC practice, all recruitments will be advertised across Europe and will be carried out in accordance with EU and equal opportunities legislation.

- A consideration by ESO in the acceptance of staff will be their ability and willingness to spend periods of time in Garching. Typically, the period will be not less than six months and may be up to the full duration of the in-kind agreement, depending on the nature of the programme.

- There will be a single point of contact on the UK side to handle all manpower acquisition tasks.

- The expectation is that the average cost of a UK staff member will be broadly similar to the average cost of an ESO staff member. Newly-acquired staff will be costed at market value."

I am pleased to inform you that PPARC agrees to the proposals contained in your letter. Your letter and this letter in reply thereto shall thus constitute an Arrangement between ESO and PPARC, which shall enter into force on the date of this letter.

Yours sincerely,
I. Halliday

APPENDIX 2 TO
ANNEX 1 TO PPA(01)44

VISTA Attachment

1. INTRODUCTION

In 1999 VISTA was approved for funding by the UK government through the Joint Infrastructure Fund (JIF) at the level of £24.8M. The award was made to the VISTA Consortium (representing 18 UK universities) via a grant to the Lead Institution for the Consortium, Queen Mary, University of London (QMUL). QMUL set up a VISTA Executive Board which recommended the appointment of PPARC as Executive Agency (EA). Following an external assessment and a VEB recommendation the EA then appointed the UK ATC as the Managing Organization (MO) for the project. The MO set up a VISTA Project Office (VPO) within the MO. The ATC proposed to carry out the project in two Phases (A and B). Phase A is now close to completion. It is important to recall that the JIF award for VISTA did not cover the scientific operation or exploitation of the facility. In the proposal PPARC undertook to set in place suitable arrangements for operation.

After special negotiations it was agreed that VISTA would become part of the UK's special joining contribution "in kind" to ESO, subject to certain terms stated by the Consortium and contained in Annex B to the 4 May 2001 "Report of the ESO-UK In Kind Working Group". As part of the deal with ESO the UK will be obliged to deliver an "enhanced VISTA" compared to what was proposed to JIF. The enhancements refer to the provision of a silver coating plant, a 4x4 rather than 3x3 mosaic of infrared detector arrays, and spare parts to allow operation of the telescope with a budget of the order of 3MDM/year. The value attached to VISTA by ESO was agreed as 90MDM which equals £28.27M (45.9M Euros) at the appropriate exchange rate. It is now believed that the enhanced VISTA with both visible and infrared cameras cannot be built for this sum and that even dropping a camera will not get the final cost down to this level. In negotiations ESO has accepted this and has agreed to the delivery of a VISTA with only an IR camera, consistent with their long stated primary interest in data from VISTA's IR camera. Neither VISTA, PPARC nor ESO can presently fund construction of the visible camera, and any future provision of the second (visible) camera will require additional funding.

2. PHASE A

In Phase A the primary vehicle for managing VISTA has been the advice of VEB, which is responsible to Queen Mary. Via the EA this was the body that has received reports and delivered instructions to the MO. Other bodies in the structure set up by Queen Mary (and detailed in the Consortium Arrangements) have included the VISTA Science Committee and the VISTA Consortium Board.

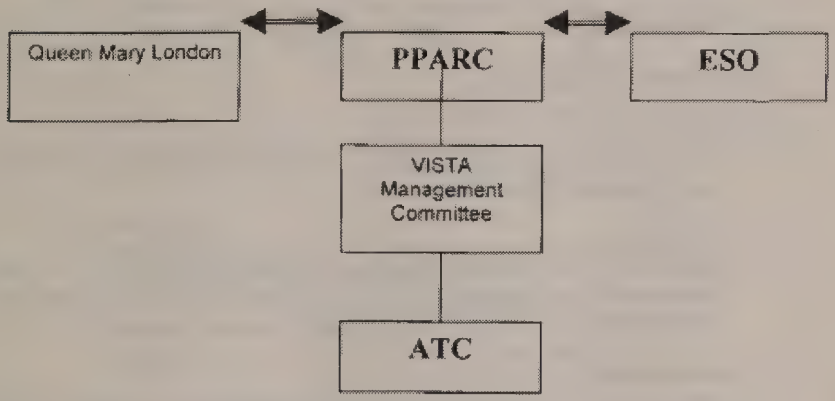
3. PHASE B

Phase B will include a set-up whereby the lines of authority and responsibility are as clear and straightforward as possible. QMUL, as Lead Institution for the Consortium, will ask PPARC to take full responsibility for project delivery (with the associated

liability). PPARC will set up a VISTA Project Management Committee (VPMC) that has the authority and expertise to get the telescope built and delivered to Chile. The VPMC will interact directly and regularly with the VISTA Project Office (VPO) team. The lines of authority and control are summarised in Figure 1. The key elements of the plan are:

- Agreements will be put into place with QMUL to cover the transfer of responsibility and liability for the use of the JIF funds and delivery of the completed project, and with ESO to cover the delivery and specification of VISTA to ESO.
- PPARC will assume full responsibility for the delivery side of the VISTA project, which will be managed through its Astronomy Technology Centre.
- Oversight and control of the project will be provided by a VISTA Project Management Committee (VPMC). This committee will have the authority to make decisions and authorise action by the ATC consistent with the QMUL/PPARC and ESO/PPARC agreements referred to above.

Figure 1. Phase B Simplified Agreement and Management Structure



4. BASIC DOCUMENTS

At the conclusion of Phase A, the following documents (see Annexes B1, B2, B3 and B4) describe the VISTA Project:

a) VISTA Project Overview
b) VISTA Science Requirements
c) VISTA Operational Concept Definition
d) VISTA Technical Specification. This was derived from the scientific specification embodied in the Science Requirements document and Operation Concept Definition document.

All these documents will undergo ESO scrutiny before being "accepted" as Basic Documents for the final VISTA Delivery to Paranal Observatory. From the date of the entry into force of the exchange of letters between PPARC and ESO these documents will be under configuration management. The optical camera will not be part of the Final Delivery.

Because the telescope will be operated and maintained as part of the ESO operation, it will be necessary to ensure compatibility with ESO systems, interfaces and procedures.

5. MAIN ELEMENTS OF THE VISTA AGREEMENT

i) Scope of the VISTA Project

The VISTA Project includes the Development & Manufacture, the Testing, the Transport, the Installation & Commissioning, the Test & Provisional Acceptance and the Final Acceptance & Handover of the VISTA 4m telescope and its associated instrumentation, facilities, spares and documentation.

ii) Deliverable Items

The deliverables by PPARC are:

- The telescope:
  A 4m-class telescope with a wide field of view and allowing two alternative camera systems (IR or visible).

- The infrared camera:
  Optimised for the infra-red band with a nominal field of view of 1.7 square degrees and populated with 16 2k x 2k infra-red detectors of pixel size approximately 0.3 seconds of arc on the sky.

- The coating plant:
  This is the mirror coating facility for coating the nominal f/1 primary mirror and the secondary mirror (though not both at the same time). This facility shall have dual capability such that aluminium or silver coatings can be produced.

- The enclosure and annex:
  For housing the telescope, coating plant, mirror coating preparation area, instrument storage and appropriate maintenance and preparation areas, personnel facilities and plant rooms.

- The computing system:
  For the necessary hardware and software for the control of VISTA and for the handling of the data.

- The necessary hardware and software for control of VISTA

- The ground-works:
  The levelling and testing of the site, the access road, ducting and services, including power distribution.

- The civil works:
  The foundations and concrete work including the telescope pier, enclosure and annex foundations, drainage, septic tanks and facilities for handling coating by-products.

- The plant and services:
  All necessary plant and services for the operation of the telescope and maintenance activities, including power, water, dry air, pumps, air conditioning and refrigeration.

- Equipment:
  All necessary special test, maintenance, handling and transport equipment.

- Safety Equipment:
  All necessary safety devices and equipment for the safe operation and maintenance of the telescope and the facilities.

- The Spares:
  The necessary spare parts, including the 'life spares' (specially produced spares at time of manufacture) and the common user spares sufficient for commissioning and the first six months of operation.

- The documentation:
  All operation, maintenance and safety documentation and manuals
  All design and development documentation
  All manufacturing, integration and test documentation
  All installation and test documentation
  All commissioning data and documentation up to handover

iii) ESO's responsibilities and deliverables

ESO undertakes, through the Exchange of Letters with PPARC, to

- ensure open access to the Site for the construction and commissioning of VISTA
- ensure the VPO and its agents have access to the site at all reasonable times
- ensure that the necessary site infrastructure for VISTA is provided
- ensure that VISTA staff, while they are in Chile, are accorded equal status with ESO staff, including the same rights and privileges
- use its best efforts to facilitate the admission into and exit from Chile of persons where this is in the interests of VISTA
- use its best efforts to facilitate free movement into and within Chile of materials, equipment and other items necessary for the execution of VISTA
- secure ESO's promised contribution to VISTA of necessary ESO staff for the duration of the design and construction phases
- arrange for ESO to provide to VPO information to ensure that VISTA is compliant with VLT standards

- ensure provision of the necessary VLT software to VISTA
- ensure that the VPO is advised of any activities, particularly those at Paranal, that may impact the schedule for VISTA
- establish arrangements to confirm ESO compliance through the review process

iv) Implementation Benchmarks

The Statement of Work (including Project Control and Reporting, the Technical Specifications and the Contract Schedule Milestones) will be elaborated and agreed upon as soon as possible.

v) Total Value

The amount of 45.9M Euros is deemed to be firm and not subject to revision except in the case of a "force majeure".

vi) Delivery date

The agreed delivery date is August 2006

Penalty for late delivery:

If delivery is after:	the value is reduced to:
August 2007	42 M Euros
January 2008	28 "
August 2008	14 "
January 2009	0 "

Any resulting reduction of the value will be compensated in cash, unless otherwise mutually agreed.

vii) Contracts

Consistent with PPARC's standard practice, which follows EC procurement rules, all contracts will be open to all ESO Member States.

viii) Allocation of Time

Allocation of time will be via the ESO-Observing Programmes Committee.

ix) Amendments

This VISTA Arrangement may be amended or terminated by mutual written agreement.

ANNEX 2 TO
PPA(01)44

1. BACKGROUND TO THE CURRENT STRATEGY FOR THE GROUND-BASED PROGRAMME

1.1 The LTSR reviewed the science drivers for the astronomy programme over the next 10-15 years and inter alia, identified the new ground-based facilities required to address those issues; these were:

- increased access to 8m-class telescopes
- access to the Atacama Large mm-Array (ALMA)
- an involvement in the development of extremely large optical/IR and radio telescopes

1.2 Of the current ground-based telescopes, the mid-term future of UKIRT was felt to be secure because of the planned and important wide-field IR survey capability. Access to reasonable optical survey imaging in the north (currently provided by the INT) would also continue to be needed. Both would complement the potentially excellent capabilities of VISTA in the South. The JCMT would certainly remain a priority as long as SCUBA remained internationally competitive and, in the longer term, SCUBA2 could be implemented on an acceptable schedule. However, it was recognised that it will be a candidate for closure as ALMA came into operation. It was felt that there would be scope for a phased restructuring of the support, development and use of the WHT, INT, JKT and AAT.

1.3 UK membership of ESO and Gemini meets the UK's needs in terms of access to 8m facilities, and through ESO we will secure the UK's position by having commensurate shares in ALMA and the very large telescopes of the future.

1.4 The Astronomy Advisory Panel met recently and their report identified ESO and Gemini as Priority 0 (i.e. beyond question), with UKIRT, JCMT (with SCUBA2), WHT, MERLIN and NGST as Priority 1. The Panel did not indicate relative priorities within the Priority 1 band.

2. THE CURRENT GROUND-BASED FACILITIES

2.1 It is against the backdrop of releasing the funds from current the facilities to enable us to meet our obligations to the ESO subscription, whilst still maintaining those facilities important to achieving the stated science goals, that the current facilities have undergone review.

2.2 Each facility has been the subject of a review of the current and possible future operating modes and costs; where appropriate this has also involved discussions and negotiations with our international partners. In the case of MERLIN, ING, JCMT and UKIRT the Directors have drawn up plans and these have been subjected to detailed reviews with international and independent membership. Additionally they have been reviewed by the relevant facility Boards. The operating modes and plans outlined in the suggested strategies are consistent with both the science priorities for the UK and with our partners' visions for the facilities.

2.3 **AAO:** A draft amendment to the inter-government agreement has been discussed within the Board and between funding agencies. This amendment would allow the UK to substantially reduce its contribution to operations (by over 80%) at the end of the minimum of the 5 years notice required under the Agreement. Under this model the UK would retain a minor shareholding to maintain access to the AAT and the instrument building capabilities of the AAO, and provide a staged buy-out with no contingent liabilities. We will need to give notice in early 2002. The final details of this agreement have yet to be agreed, but the assumption in this paper is that the UK contribution to the cost of operations will decline by c£100k p.a. until 2006/07 when the UK contribution will be limited to (Australian)$500k. However, while the figures for 2006/07 and beyond are 'firm', the reductions in the period 2003/04 to 2005/06 are still subject to negotiation. The proposed new agreement states that, on a best effort basis, the UK would place instrument work at the AAO, for which we would be entitled to additional telescope time. An alternative to the new agreement would be to withdraw completely after 5 years notice, saving c£600k in total over the remaining 3 years, but incurring frictional and decommissioning costs which are unlikely to be less than £1M, and possibly as high as £2M. Our partners would be unlikely to agree to rescind the current agreement early, and it assumed that the UK would not wish to, and not be allowed to, unilaterally withdraw from an inter-government agreement *Decision point: Now*

2.4 **JCMT:** The future strategy for the JCMT is linked with the availability of SCUBA-2, in terms of both the scientific priority and the operating model. The current development programme will culminate in the array Critical Design Review (CDR) in October 2002. Only then will be it become apparent whether the instrument can be delivered on the JCMT in a timely manner, ensuring proper exploitation before the end of the current agreement in 2009. The funding situation will also need to be reviewed in the light of the agreed savings model, a bid to a Canadian infrastructure fund (matching the UK bid to the OST) and, perhaps, the outcome of SR2002. All this will come together for a decision in the autumn of 2002. In the meantime we are planning on the basis that SCUBA-2 will be built for the JCMT, and that the UK does not have to put operational savings towards the instrument. In the spreadsheet this is expressed as a broadly cost neutral contribution to the development phase with the cost being found from existing JCMT development and operating funds, but with PPARC providing the cashflow. (In this model the OST funds are not used). It is assumed that in moving to the build phase the funds will be found from the new money from the OST and Canada. The worst case scenario, where no additional

Canadian funds are forthcoming and all the partners will be required to use their share of the operations savings to fund the instrument, is shown as unapproved new programme, with a net cost to the UK that (more or less) expunges the operations savings.

2.5 The Director brought forward three savings models and these were reviewed by an independent panel. The Panel reviewed the whole JAC operation, including UKIRT. This was essential because the savings models depend on the opportunities for joint working and sharing of staff and services between UKIRT and JCMT (and the costs of either would increase if the other was closed). The first model was very much a natural progression from the current position, based on moving increasingly to a survey mode of operation. The savings can probably be achieved through normal staff turnover. The second, 'moderate', model built in a steeper and deeper decline in staff numbers (which are the main cost drivers) and exposed some risks to the operation, but they are clearly identified and considered to be manageable. The more aggressive model carried very much higher risks for the effective operation of the facility and these would be unacceptable to our partners and our own community. The independent panel and the JCMT Board recommended the moderate model and that is our working assumption. The risks of failing to meet the savings target are small, and there is always the possibility that savings can be increased. Maximum potential frictional costs are built into the assumptions, thereby increasing the 'safety margin' in terms of guaranteeing minimum savings. The small-scale savings to be made in the first few years are not dependent on the long-term direction for the JCMT and therefore decisions on the way forward can be taken after a decision on SCUBA-2 (October 2002). Without SCUBA-2 on the JCMT its medium to long-term future would need to be reviewed, with closure before the end of the current agreement (2009) a possibility. However, depending on when ALMA was to become operational, there might still be a valuable longer-term role for the JCMT in interferometric programmes with the SMA. Until the SCUBA-2 situation is clarified our partners are unlikely agree to earlier withdrawal and therefore there could be punitive penalties to UK for unilateral action (c£10M). *Decision point: autumn 2002 when we know the outcome of the Canadian bid for infrastructure funds, the result of the CDR and the outcome of SR2002.*

2.6 **UKIRT**: On completion of WFCAM, UKIRT will move to operating largely in survey mode. In keeping with the assumptions made for the JCMT we have adopted the 'moderate' savings model, encompassing the same risks and opportunities. However, it should be noted that because many of the savings on UKIRT and JCMT are dependent on joint activities, the savings on either would be reduced by up to one-third if the other telescope were to close. Formally there are no partners to consider. However, it should be noted that the WFCAM surveys form part of the 'in-kind' contribution to ESO. We are also 'bound' by an MoU with the Subaru telescope whereby the Japanese make contributions to WFCAM and UKIRT operations in exchange for access to survey data. In the absence of a formal agreement with partners, early closure would be less costly, but again there would still be large up-front costs of closure and in providing funds in lieu of the in-kind contributions UKIRT is providing. *Decision point: Now*

2.7 **ING:** The recent AAP report endorsed the outcome of the LTSR by confirming that the WHT has a strong strategic role to play in the near-medium term future. This is supported by the fact that the WHT was recently identified as being within the top three leading optical/IR facilities in its class in terms of scientific productivity and citations. A recent, independent, panel reviewed the plans and options put forward by the Director, and endorsed by the ING Board. The Panel concluded that with a rationalised instrument suite (including the use of the OASIS integral-field spectrograph) and closer working with Spanish astronomers and others on La Palma to provide economies of scale, the costs could be reduced significantly. Furthermore, with an increase in support from the Spanish, the cost to the UK would fall to less than 50% of its current level. In view of this the optimum route would seem to be to adopt the plan discussed by the ING Board and approved by the NWO and IAC (our partners). This plan includes withdrawal from JKT now, the INT soon and has the UK retaining a smaller share of WHT (60% to 48%) until the end of current agreement in 2009. Of course, this would not preclude the partnership keeping the relative priority of the WHT under review between now and 2009 and a 'mid-term' review would be appropriate. Under the terms of the current agreement, early unilateral action could result in punitive penalties in the first two to three years (a point confirmed at agency level in the Netherlands) and decreasing long-term savings. Taking account of penalties and frictional costs, the net savings accruing to PPARC between now and 2009 would be approximately £4M if the UK were to withdraw in 2002, £0 if we were to withdraw in 2003 and losses if we withdraw in 2004 or later). *Decision point: Now*

2.8 **Gemini:** UK astronomers will not get full access to the VLT until 2003 and therefore in the short to medium term Gemini has absolute priority in the programme. As a consequence no changes are planned to the current provision. In the longer term we should look for opportunities to reduce commitments to Gemini South. One option might be to sell time to Australia. After the 'Abingdon 2' review of future instrumentation (mid-2002), the Gemini Board will wish to consider the future budget to take account of the second-generation instrument programme. There may be pressure from other partners to increase contributions to the Instrument Development Fund. *Decision point: 2-3 years from now*

2.9 **Liverpool Telescope:** Support has been agreed for first few years and we should review in two to three year's time.

2.10 **(E-)MERLIN:** E-MERLIN was identified as a Category 2 priority by the LTSR and Priority 1 in the recent AAP report, both recommendations made on the assumption that the capital cost of E-MERLIN was secured through non-PPARC funds. The science that could be delivered with E-MERLIN would fit well with the AAP's strategic vision. The facility could exploit a window of opportunity prior to the development of the EVLA (which is the planned upgrade to the U.S. Very Large Array). Until recently it has been assumed that this development would not be completed before the end of the decade, providing, say, a 5 year window of opportunity for e-MERLIN. However, recent news from the US indicates that a decision on the approval of funds for the

EVLA might be made in the near future. If positive it might be expected that the EVLA would be operational in 6-7 years, perhaps reducing the window of opportunity from 5 years to 2-3 years. In terms of its spatial resolution, there will still be an area of unique for e-MERLIN when the EVLA is operational, but some might argue that the science case is weakened.

2.11 Within the current portfolio MERLIN is the one facility that could be closed without reference to partners and with little or no contingent liability. A recent, independent, review of the running costs showed that the current running costs of £2.3M p.a. could be reduced to £2.0M p.a. whilst still retaining the complete programme. However, it was noted that this would be a higher risk operation, with the potential for more single point failures and sequential rather than parallel maintenance and repair capabilities resulting in more downtime. Reducing the costs below £2M p.a. would lose significant capability, in a non-linear fashion. The current planning assumption is at the minimum, higher risk, level of £2.0M p.a. For planning purposes the assumption made is that if risks are to be mitigated any additional funds should come from the Jodrell science programme or additional income, for example by use as a back-up ground station for ESA. From a purely PPARC perspective a decision is not needed now, and could await the outcome of SR2002 and the recent developments on the EVLA. However, there is the threat of the 'external' funding for E-MERLIN capital being withdrawn unless positive decision made before the end of the year. *Decision point: Now?*

2.12 **Savings from the ground-based programme**

The table below shows an estimate of the minimum net savings from the proposed restructuring 'plan' outlined above (i.e. with the estimated restructuring/decommissioning costs built-in) (£k cash planned):

	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12
AAO	0	100	254	408	1018	1391	1426	1462	1498	1536
JCMT	95	95	133	171	452	464	475	487	2293	2351
UKIRT	0	0	267	267	396	406	416	426	437	2253
ING	535	956	1384	2207	2338	2319	2376	2877	4307	4435
MERLIN	166	425	435	447	457	468	480	493	505	517
TOTAL	796	1576	2473	3500	4661	5048	5173	5745	9040	11072

In terms of lost capacity, a summary of the consequences of adopting this plan are as follows:

- AAO: By 2007/08 reduction in UK time from 50% to 7% (although this could be increased if AAO undertook work for the UK instrument programme);
- JCMT: With SCUBA-2, predominately a survey telescope by 2006/07; without SCUBA-2 the priority of the JCMT would need to be reconsidered;
- UKIRT: Predominately (>75%) a survey telescope by 2005/06;

- ING: Closure of JKT and INT. UK WHT time reduced from 60% to 48%;
- MERLIN: Higher risk operational mode, possibility of increased down-time.
- Under this plan the UK will have withdrawn from the AAO, WHT, UKIRT and JCMT by the end of this decade

Clearly this model falls a little short of the target of savings of £5M p.a. by 2005/06, however, it should be noted that the savings in the early years more than compensate for the in-year 'shortfalls' in 2005/06 and 2006/07. Furthermore, the savings rise to double that amount in the second half of the period. The savings indicated above have been subjected to rigorous and independent review and are believed to be the optimum in terms of minimising science loss, reaching agreements with partners to whom we have formal commitments and 'achievability' in terms of the management of change. Furthermore, with the restructuring cost built in these are the minimum, low risk, savings. In this context it should be noted that the 'preferred' model for the ING and the 'moderate' models for UKIRT and JCMT still result in the loss of 48 posts in Hawaii and La Palma, a significant management challenge.

2.13 There are limited opportunities for steeper and deeper cuts, and many must be considered to be sub-optimal. However, on the assumption that the AAO plan is the most cost effective model for that facility in the long-term (and that under the agreement it will not be possible to make substantial savings in the short-term) and that UKIRT is too high a priority to consider early closure, the possible alternative and more aggressive savings might be:

- early withdrawal from MERLIN, would save additional £2M p.a. with no frictional costs;
- immediate withdrawal from ING, would result in additional costs (c£12M) in first few years, and savings of c£1600k p.a. thereafter. Net saving over 8 years approximately £4M.
- the early closure (say 2006/07) of JCMT, in agreement with our partners, would result in high frictional costs in years leading up to closure, perhaps £0.5M p.a. from 2003/04 to 2006/07, and decommissioning costs, say £2M, in 2007/08. Net savings over current model approximately £3M. Early withdrawal without the agreement of our partners would increase the UK's share of frictional costs and add £7M, this being the approximate capital repayment. The total cost of early unilateral action might be £10M, with a saving of £4-5M over the decade.

ANNEX 3 TO
PPA(01)44

SCIENCE COMMITTEE RECOMMENDATION ON FUTURE FUNDING OF THE GROUND-BASED PROGRAMME IN THE CONTEXT OF THE UK'S MEMBERSHIP OF ESO

1. At its meeting on Nov. 27/28th 2001 in Swindon, the Science Committee considered the various options within a Strategic Plan for Astronomy, that would enable PPARC to fulfil its commitment to make the necessary saving of 5M pounds/pa by 2005/6 from the current ground-based programme, to meet the financial requirements for the UK's accession to membership of ESO.

2. The SC considered the package of savings set out in the paper SC(01)44 and Annex 2 to PPA(01)44, which focussed specifically on the major facilities ie. AAO,ING, JAC and e-Merlin. Earlier in the year target savings had been identified but now, in consultation with the facility's Directors, detailed reviews and risk analyses have been carried out. After a detailed discussion, the SC formed the opinion that the savings described in SC(01)44 and Annex 2 to PPA(01)44 effectively meet the requirements necessary for the UK to proceed to ESO membership, whilst in the medium term permitting focussed and highly cost effective participation at a reduced level in the world-class science output from existing facilities.

3. However this package of savings does not address the considerable pressures that exist across the whole programme. The only realistic option to provide further savings from within the ground-based programme beginning in the medium term, would be a decision not to provide the operating costs for e-Merlin at 2M/pa. In recommending that PPARC commit to the package at this time, including e-Merlin operation costs, the SC is concerned about the possible impact on other high priority items within the programme.

4. In conclusion, and based on savings package now identified, the SC recommends to Council that the UK should accede to membership of ESO.

Further supplementary written evidence submitted by Science and Technology Facilities Council (STFC) (APP 33c)

STFC Particle Physics & Astronomy	*2005–06*		*2006–07*		*2007–08*		*2008–09*		*2009–10*		*2010–11*	
Resource and Capital	*(£m)*		*(£m)*		*(£m)*		*(£m)*		*(£m)*		*(£m)*	
	Resource	*Capital*	*Resource*	*Capital*	*Resource*	*Capital*	*Resource*	*Capital*	*Resource*	*Capital*	*Resource*	*Capital*
PP Studentships/Fellowships	6.07	0	6.66	0	7.41	0	7.8	0	9.07	0	9.6	0
A Studentships/Fellowships	9.45	0	10.38	0	11.54	0	12.15	0	14.12	0	14.95	0

General Notes

Accounting years 2005–06 and 2006–07 reflect data from STFC predecessor councils, PPARC and CCLRC

fEC applied to exploitation grants from 2007–08 onwards

Figures provided for 2010–11 are an in-year forecast.

Astro Notes

Excludes repayment projects

Excludes Band 38 Income

Split between ground based and space is approximately 60/40

PP Notes

Excludes FP6/7 projects

Grants and Non grant costs (CERN M&O etc) included

PP Includes PA & PRD

PP does not include Theory, HPC, E-Science, Science Strategy and SiS

STFC Resource budget by funding mechanism (net resource)	*2005–06 (£m)*	*2006–07 (£m)*	*2007–08 (£m)*	*2008–09 (£m)*	*2009–10 (£m)*	*2010–11 (£m)*
Research Grants	63.83	67.82	87.33	98.38	100.74	94.06

Notes

Figures provided for 2010–11 are an in-year forecast.

fEC applied to exploitation grants from 2007–08 onwards

Accounting years 2005–06 and 2006–07 reflect data from STFC predecessor councils, PPARC and CCLRC

These figures include the STFC Space Science and Space Exploration Programme (and that of STFC predecessors). These grants transfer to the new UK Space Agency from April 2011. Details of 2010/11 transition arrangements can be found here—http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/445/445w12.htm. The commitment to these grants in 2010–11 was £20.75 million, and in 2011–12 is £20.2 million.

Statistics on STFC grants, fellowships and studentships can be queried online here—http://www.stfc.ac.uk/webstatistics/stfcStatistics.aspx

Written evidence submitted by senior figures within the UK experimental particle physics, theoretical particle physics and astro-particle physics communities (APP 34)

The House of Commons Science and Technology Select Committee is today launching an inquiry into astronomy and particle physics in the UK, and in relation to these, invites views on the following:

1. The Impact of Reduced Capital Funding on UK Capability

1.1 Since schools have little access to high-technology equipment, the only exposure of students is at undergraduate level (mainly through project work with active research groups) and, obviously, at postgraduate level. Capital cuts will hit both of these hard, impacting on student recruitment to STEM subjects and on the quality of training that can be provided to graduates, leaving them ill-equipped for the highly competitive global economy (where other countries do provide student exposure to cutting-edge technologies). A lack of new equipment is further exacerbated by the cut-backs in new capital projects on which UK students and post-doctoral researchers can train. The proposal, as we understand it, to concentrate new equipment at STFC centres as discussed below, would have a disastrous effect on the training of the next generation of scientists, essentially all of which takes place at universities.

1.2 The cuts in capital funding, both in their implications for equipment grants to universities, and given the high fraction of STFC costs associated with facilities and international subscriptions, further erode a research base which is still reeling from the consequences of the underfunding of the PPARC-CCLRC merger to create STFC in 2007. This manifests itself in the statement below, from page eight in the STFC Delivery Plan, which appears to imply that major reductions to the grant support for university based technology research and development are being planned. (See http://www.stfc.ac.uk/resources/pdf/DP2011–15.pdf *"We will foster a complementary partnership between STFC and universities by increasingly focusing the capabilities of STFC's in-house researchers on technology, instrumentation and detector development, leaving university scientists to concentrate on scientific research."*). Historically, STFC and the universities have worked in partnership very effectively, most recently on the LHC, and it is surely very risky to upset the broad parameters of that partnership. The proposal also misses the fact that the majority of recent particle physics technology development, detector construction and sub-system delivery to experiments has had a strong university lead, with many of the recognised international experts employed (often on STFC grants) in the university sector. This proposal also flatly contradicts the requirement on universities groups to be able to demonstrate impact from their scientific programmes, since much of their spin-out and links with UK industry rely on this university based technological expertise, backed by strong in-house capabilities.

1.3 Experimental particle physics requires those who exploit the data to be directly involved not only in specifying the highly demanding technical requirements, but also in developing the new technologies required to meet the unique challenges. Given that this is also the practice for all the international partners with whom we collaborate, any UK-specific changes of the nature discussed above would both undermine our leadership in technology development and make it even harder for UK industry to compete successfully for contracts in this area.

2. The Impact of Withdrawal from International Ground-based Facilities (for Example the Gemini Observatory and Isaac Newton Group of Telescopes) on the UK's Research Base and International Reputation

2.1 The termination by STFC, in its 2009 Delivery Plan, of UK participation in the International Linear Collider programme (see http://www.stfc.ac.uk/resources/pdf/delplan_07.pdf), without any consultation and after years of PPARC encouragement for universities to invest staff and effort into this major worldwide project, has impacted very negatively the UK's reputation for reliability in international collaborations.

2.2 It is impossible to do world-leading science with second—or third-rate equipment. It is also impossible without active participation in the ongoing international programmes to enhance the capabilities of existing experiments or to define and develop new projects. Too many opportunities have been wiped from the current STFC "roadmap" for particle physics, with examples including: LHCb upgrades, direct dark matter searches, gamma-ray astronomy and SNO+. The focus is now undeniably too narrow, sending worrying messages about the scope in the UK to carry out innovative science, particularly to young researchers who may feel other countries offer much greater opportunities.

3. Whether the Science and Technology Facilities Council (STFC) has Sufficiently Engaged with its Research Community in these Two Areas on its Strategic Direction and Impacts of Budget Reductions

3.1 The academic communities involved with STFC science continue to lack confidence in the Chief Executive of STFC (as evinced by a recent petition signed by a substantial fraction of STFC's researchers and referred to recently by Professor George Efstathiou http://telescoper.wordpress.com/2010/10/04/guest-post-stfc-it-isnt-just-about-money/). In its response to this petition and other evidence of unease about the Chief Executive's performance in a wide variety of areas, STFC Council drew up a blueprint for the next STFC Chief Executive (see http://www.stfc.ac.uk/resources/PDF/SummaryReport.pdf).

However, there are no recent signs of any progress on this front and minutes of STFC Council have stopped being made publicly available since March 2010 (ie from the last seven or so meetings). This raises concerns of a reversion to the culture of secrecy so robustly criticised in 2008 by the Innovation Universities Science and Skills Select Committee (see the Fourth Report: http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/215/21506.htm#a23). By way of contrast, we note for example that the Council of the Natural Environment Research Council publishes the agenda and papers (with the exception of a few "management in confidence" papers) for all its meetings on its web site (see http://www.nerc.ac.uk/about/work/boards/council/meetings.asp).

3.2 Although many STFC senior staff have a scientific background, too many of its public pronouncements seem to deliberately aim to obfuscate rather than illuminate and are couched in the worst sort of unintelligible management jargon. Perhaps even more damaging is the evident lack of leadership—there is no clearly articulated vision, and it is not clear where responsibility lies within STFC for defining and communicating such a vision. Their slogan (*"Excellence with impact"*) contains no scientific ambition, and is hardly designed to attract the best young graduates into their science areas. On a much more positive note, during the immediate preparations for the CSR and in aspects of the implementation planning, some senior staff have made significant and highly appreciated efforts to engage with the scientific communities affected.

3.3 In comparison to EPSRC, MRC and NERC, STFC Council has anomalously low representation of senior academic researchers (see http://www.ast.cam.ac.uk/~gpe/smith.pdf). No convincing reason has ever been given for this and it gives undue influence to members of Council who are on record as being unsympathetic to the basic aims of STFC research (see http://www.guardian.co.uk/science/life-and-physics/2010/sep/04/spending-review-investment-in-science).

3.4 The posts of Director of the Rutherford Appleton and Daresbury Laboratories were also abolished in 2007 resulting in a vacuum of leadership in the UK's national laboratories. This situation is also highly anomalous and in stark contrast with best practice around the world.

4. Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

4.1 Removal of funding from awarded research grants that started October 2010, and the issue of just one year grants prior to that, created havoc for particle physics groups across the UK and has led to a situation where talented young people see the UK as offering no immediate job prospects and poor future employment. This exacerbates the problems caused by the initial underfunding of STFC. A generation of students graduating with UK PhDs are leaving the country to continue working in the field they love, and many will not return.

4.2 The high visibility of Professor Brian Cox, and the hard work on outreach by many colleagues in particle physics, have resulted in the subject having a higher than ever profile with the public and the media. In the two weeks previous to writing this submission, substantial articles were published on particle physics in the Independent and Times newspapers and extended interviews broadcast with senior particle physicists on BBC TV, BBC Radio 3 and 4 etc. This supports the very widespread engagement with schools, with most high energy physics research groups also offering the extremely successful Particle Physics Masterclasses (see http://www.particlephysics.ac.uk/teach/master-classes.html) and going into schools to enthuse students with modern science and technology. For example, an Oxford graduate student was supported to develop a new show for younger school students "Accelerate!". This has been an enormous success, and since the originator and several of the presenting team are female, it provides badly needed female role models to help increase the interest of girls in taking up physics, where they are grossly under represented. However, this excellent outreach is undermined by cutbacks to the very projects they find exciting. It is difficult to reassure a student inspired by outreach to contemplate a career in physics and astronomy if newspapers are full of stories of cutbacks and members of STFC Council denigrate the very research they are paid to advance.

4.3 Another notable success is the way the Large Hadron Collider has entered popular culture, where it features regularly in comments in programmes as diverse as Start the Week, the Today programme and numerous panel games on television. Many members of the public have heard of CERN, the LHC and the Higgs particle (although perhaps not realising that this is named after a UK physicist), and are keen to meet with particle physicists to learn more. STFC have played a very significant part in promoting the LHC and in publicising the start of high energy collisions on 30 March 2010. The Large and Small Awards Scheme in outreach is also extremely valuable, supporting, for example, the development of the "Accelerate!" lecture referred to above. However, some time ago, STFC discontinued production of a wide range of publicity material that had been extremely useful for particle physicists engaged with either schools or the general public. When this was queried in an email by a senior member of the particle physics community to the STFC CEO, he received no reply.

This Submission is presented by the following senior figures within the UK experimental particle physics, theoretical particle physics and astro-particle physics communities.

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13 February 2011

Written evidence submitted by the Astrophysics Research Institute, Liverpool John Moores University (APP 35)

Introduction

1. The Astrophysics Research Institute (ARI) of Liverpool John Moores University (LJMU) has a staff of 23 research astronomers, 16 PhD students and 12 technical and support staff. In an innovative collaborative arrangement it provides all the Astrophysics undergraduate degree teaching in a joint degree with Liverpool University. It also owns and operates the 2.0 metre Liverpool Telescope (LT) on La Palma, which is a unique robotic facility for time domain astrophysics for all UK astronomers. Funding for the operation of the LT is in part supplied by STFC. Use of the LT also naturally forms the principal focus of many of the astronomers within the ARI. Another unique feature of the ARI is its very strong outreach and education programme, where access to the LT is made available to schools across the UK via the National Schools Observatory (NSO) and also to students on specific modules of ARI's large Distance Learning programme. Both the research within ARI (evidenced by for example the grant awarded within the last two weeks to Prof Carole Mundell by STFC for Gamma Ray Burst research using the LT) and its impact on the wider world (as evidenced by the recent HEFCE physics impact pilot,[31] where the ARI was awarded the highest score of all 13 physics departments entered, including some of those at the very top of the outcomes in the 2008 RAE in physics) are independently rated as of the highest international standard.

2. The particular concern of ARI is potential UK withdrawal from the La Palma site. For the UK, this hosts the STFC-owned and operated Isaac Newton Group of telescopes (including the William Herschel Telescope), SuperWASP (Wide Angle Search for Planets, owned and operated by Queens University Belfast) and the Liverpool Telescope (LT). Withdrawal would have a devastating effect on our ability to conduct world class research and outreach. In addition withdrawal from La Palma would also seriously affect the many users of these facilities in other departments across the UK.

The Impact of Withdrawal from International Ground-based Facilities...on the UK's Research Base and International Reputation

3. The overall strategic body for planning future astronomical developments across Europe is ASTRONET[32] which was created by the major European funding bodies and research organisations in astronomy, including STFC. ASTRONET carried out the most comprehensive consultation exercise ever undertaken by European astronomers to draw up a Science Vision encompassing the next 10–20 years. It then drew up a Roadmap which identified the highest priority facilities and other capabilities required by Europe to deliver the Science Vision. For example, in ground-based astronomy, the highest priority large projects were found to be the European Extremely Large Telescope and the Square Kilometre Array. The Roadmap also recognized the need for some restructuring of the organization of Northern Hemisphere 2–4m class facilities across the whole of Europe. It therefore commissioned a detailed review by the "European Telescope Strategic Review Committee" comprising 10 leading astronomers, chaired by Professor Janet Drew (Univ. Hertfordshire), with considerable community involvement. The report is available for download at http://www.astronet-eu.org/IMG/pdf/PlaquetteT2_4m-final.pdf and we commend it strongly to the committee as the most thorough and comprehensive independent review of the question of the future of the northern hemisphere 2–4 m telescopes.

4. We quote from the very first paragraphs of the report:

> "The panel wishes to note at the outset the general point that it became ever more vivid as it carried out its task that astronomy, as an observation-driven discipline, confronting phenomena ranging from the very bright (naked eye exo-planet hosts and astroseismological targets) to the faintest quasars at the edge of the accessible universe, continues to need access to telescopes in all size classes ... In this respect, our subject is not at all like some other frontier disciplines such as particle physics where it is clear that advances demand a policy of complete facility replacement on decadal time scales. The 2–4 m class telescopes support a wide range of research topics and it can indeed be argued that they can offer cutting edge science ... It is also worth noting that there is a rising profile of interest in time domain astronomy, which may involve having the flexibility to respond quickly at [optical/infrared] wavelengths to triggers ... Retaining a broad suite of efficient 2–4 m telescopes accessible to Europe's astronomers is, without any trace of doubt, crucial for Europe's presence at the astronomical frontier."

5. The report then went on to identify five key capabilities which Europe needed to maintain or develop access to:

(a) Wide-field multiplexed spectrograph on a 4 m telescope.

(b) High resolution spectroscopy.

(c) Low resolution spectroscopy.

(d) Wide field imaging on 4 m telescopes.

(e) Time domain photometry.

[31] http://www.hefce.ac.uk/research/ref/pubs/other/re01_10/ (in Addendum)

[32] http://www.astronet-eu.org/

6. The committee identified the combined suite of La Palma 2–4 m class telescopes (WHT, INT and LT) with their associated instrumentation as providing key UK capabilities in areas (a) (using the current WHT WYFFOS and the planned WEAVE), (c) (using the WHT ISIS, INT IDS and LT FrodoSpec) (d) (using the INT WFC) and (e) (using the LT RATCam, LT RISE and planned LT-IO). The UK has no involvement in (b), however this is reasonable—we don't have to "do it all"! However it is clear that continued operation of the La Palma observatories will mean the UK is already well placed to lead many areas of world-leading astronomy for the next 10 years.

7. A particular interest of the ARI is of course the Liverpool Telescope. The LT was designed and built on Merseyside as the first professionally sized and equipped robotic telescope in the World. It remains the World's largest fully autonomous robotic telescope with a full, and growing, suite of professional instruments. It was sited on La Palma in order to benefit from the operational and scientific synergies of being located with the Isaac Newton Group, which provides for example a generator-backed electrical supply and regular re-aluminization of our optical mirrors.

8. The Liverpool Telescope provides a unique UK facility because it is the only robotic telescope the UK has access to as of right, and is by far the most capable internationally. This means it can automatically react to changing events in the sky such as the explosions of Supernovae or Gamma Ray Bursts much faster than a conventional telescope (typically three minutes from the satellite-generated alert for a GRB for example). This allows unique, world-leading science to be done, as evidenced by the very high proportion of papers based on LT data that have been published in the highest impact journals Nature and Science (8.5%) rather than general astronomical journals. In this context, we note that the published shortest period between a satellite alert and a polarisation measurement being made for a GRB is 12,960s for the ESO VLTs compared to 160s for the Liverpool Telescope.[33] The LT work on GRBs was awarded the Times Higher Research Project of the Year (across the whole of science) in 2007.

9. As a northern hemisphere robotic telescope, the LT will be invaluable in the confirmation of new discoveries from the LOFAR radio telescope which is just beginning operation, also in the northern hemisphere. A major EU ERC grant has just been awarded to Southampton University to employ a large team (one staff member and four postdocs) there to detect transient phenomena in the LOFAR data and follow them up using the Liverpool Telescope. Similarly an STFC-funded group at Cambridge is responsible for detecting transients from the ESA Cornerstone satellite mission Gaia. As a satellite, Gaia will observe the whole sky and therefore northern hemisphere facilities such as the LT will remain vital to ensure that follow-up on Gaia's discoveries is maximised.

10. The northern hemisphere remains a crucial hunting ground for the discovery of the first Earth-mass planet in another solar system. The UK SuperWASP project on La Palma detects more massive exo-planets, which are then monitored by the LT to search for evidence of smaller bodies in the system. The co-location of ING, SuperWASP and LT means all facilities collaborate in this effort—ING providing operational staff support to SuperWASP and LT holding spares in common with it. Expanding and deepening such collaboration is a natural way forward for the La Palma observatories to maintain science output in an era of decreasing overall funding.

11. The majority of the cost of the development and build of the LT was funded by LJMU through non-Research Council sources. The approximate current operating cost of the telescope is £650k/year. The LT currently receives an operations grant of around £500k/year from STFC. Further operational support comes from LJMU at a cost of £150k/year. In addition LJMU has continued to invest heavily in the development of new instrumentation for the telescope, for example a new combined optical-infrared camera ("IO") is being built with in-house funding of approximately £400k.

12. ARI recognizes the cost constraints imposed by the new financial environment and has put in place a programme of cost reductions achieved through a process of voluntary redundancies which will reduce the cost of operation of the telescope by 23% over the next two years, leading to an annual operating cost of around £500k/year. In addition we recognise it is unlikely that STFC will be able to cover that full operating cost after 2012. We have therefore begun a search for additional partners who can share operational costs, with the aim of significantly reducing the STFC contribution from 2012 onwards. Two partners have already agreed to participate, and negotiations are at present in progress with them. To allow this to succeed however, we need assurance from STFC that they can continue to provide operational support at a complementary level, thereby in turn giving assurance to our partners that they will be buying in to a facility with a long-term future.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

13. Astronomical outreach and education has a very important role, not just in inspiring the next generation of astronomers, but much more widely in helping to fill the gap in future provision of experts in all areas of science, technology, engineering and mathematics (STEM). This was highlighted in the extensive study *Pupils' and Parents' Views of the School Science Curriculum* by Osbourne and Collins[34] in 2000 who concluded that "The one topic (amongst the sciences) that generated universal enthusiasm was any study of astronomy"—

[33] Steele et al., 2009, Nature 462, 767

[34] http://www.kcl.ac.uk/content/1/c6/02/21/14/pupils.pdf

indeed they found this across age, gender and ethnic boundaries. A central role of astronomical outreach, therefore, is to take that ongoing enthusiasm and turn it into a wider enthusiasm for all STEM areas.

14. This is an area where the UK currently has a world-leading reputation. Projects such as the National Schools' Observatory (NSO) and the Faulkes Telescope project, the success of International Year of Astronomy (IYA2009), the leading role in the creation of "Dark Skies Parks" and many more all show the success that the UK has in exploiting the draw of astronomy.

15. However, to retain that position (and ensure the benefits to all STEM subjects are not lost) then it is necessary to both continually innovate and develop new projects *and* ensure the support for the best existing ones. The situation of the NSO is a good example of the opportunities and problems currently facing both of these.

16. The NSO, which is run by the ARI, is designed to exploit access to the Liverpool Telescope to showcase both the scientific nature of astronomy, and the exciting technology that underpins it. To do this, an essential aspect of the design and operation of the project is to explicitly work alongside professional astronomers, using similar systems to obtain and analyse observations and facing similar challenges. The main role of the NSO, therefore, is to create and support tools that allow this for a wide range of age groups (KS2 to post-16), abilities (special needs through to the highest ability) and subject areas (not just science, but also mathematics, ICT, Design and Technology etc).

17. In all this, the linkage to world-leading research is clearly essential—it is very important not just that the telescope is very large and highly sophisticated, but that it is the same telescope that is being used by UK astronomers to make headline grabbing discoveries. That connection is what will inspire pupils to believe that they too could make such discoveries for themselves in the future.

18. The NSO currently has over 2,000 schools registered. The majority of these are state-funded secondary schools with a national geographic spread. More than 24,000 observing requests have successfully been carried out for schools since the start of operations in late 2004, and the rate of requests is increasing rapidly (there were 7,000 requests successfully delivered to schools in 2010, and more than 1,400 in January 2011 alone). In addition to use by registered schools, the NSO website receives between one million and two million "visits" per year, the majority from within the UK. Drops in traffic during half-terms show that this is use by schools. Projects undertaken by pupils range from simple observations of planets or the moon, through to genuine research projects such as the study of asteroids, monitoring of distant supernovae and searching for extra-solar planets.

19. As well as direct benefits, the NSO provides a focus for other education and outreach. For example, as part of IYA2009, NSO astronomers gave inspirational presentations to about 15,000 KS4 pupils across the country. Teacher training is also an important component of our work, with hundreds of teachers each year being provided with CPD by NSO staff. In recent years this has often supported the provision of GCSE Astronomy in schools—one of the fastest growing qualifications in the UK and often taught in out-of-school clubs, which is another indication of the inspirational power of astronomy.

20. This is, therefore, a very successful and stimulating science education resource with strong links to current research. However, the funding of the project is an ongoing problem, something shared with much of the rest of astronomical outreach in the UK.

21. The initial setup of the NSO was supported by funding from PPARC and LJMU. Once established, funding was switched to a model where schools paid for an annual subscription. However, there were significant problems with this approach, both in terms of allocating appropriate funding within schools and administration at both ends. It should also be noted that, even with this funding from schools, it was only possible to support the direct costs associated with the NSO. The costs for the telescope time were absorbed by LJMU.

22. Direct funding at any significant level from central educational bodies (the Ministry, LEAs etc) has also not been forthcoming, as these bodies see such exploitation of research facilities as falling within the remit of the research councils. In contrast STFC (and previously PPARC), within limited funds for outreach activities, have perhaps inevitably given low priority to supporting ongoing projects—they are interested in developing new initiatives. Therefore the NSO, like many other outreach and educational projects, falls between two stools. External funding (whether from STFC, the EU, charities etc) requires new projects which, while worthwhile, cannot exist without the underlying support from the NSO staff, resources and network of teachers.

23. Currently the NSO itself is funded entirely by LJMU, who pay both for the running of the project (presently totalling around £150k/year) and in addition provide the telescope time from its reserved fraction. However, with the change in funding of universities, combined with the uncertainty in the continued operational support of the LT long-term from STFC, this is no longer a tenable situation. Alternative funding avenues are being explored (including commercial exploitation or extensive new developments into Europe) but even if successful these will, by their very nature, restrict or destroy the ability of the NSO to offer free access to those very schools that have the most to gain.

24. It should also be noted that an alternative model, should the LT not be available, would be to run the NSO via access to other telescopes. However, the NSO is designed to exploit the fully robotic nature of the LT, with its extensive instrumentation suite and location on an international observatory site. Moreover, if a

suitable telescope could indeed be found, which currently would be outside STFC's and ESO's remit, such telescope time would need to be purchased which would clearly be far more expensive than "piggy-backing" on the UK research effort. Since the unique current dual use of the LT by UK astronomers and schools also has significant inspirational and educational advantages, this is very much the preferred approach.

25. This specific case of the NSO, therefore, highlights a significant problem in the current astronomy education and outreach effort. The UK has a world-leading role in developing exciting new links between research and education that are essential if we are to inspire the next generation of scientists and engineers. However, once those links have been developed and are shown to be effective, there are no clear routes to support their continuation and they may die. While such issues fall between the Research Councils and DfE, and neither are willing and/or able to take ownership, this unfortunate situation will continue.

Prof Mike Bode
(Director, ARI)

Prof Iain Steele
(Director, Liverpool Telescope)

Dr Andrew Newsam
(Director, NSO)

Prof Chris Collins
(Professor of Cosmology)

Prof David Carter
(Professor of Observational Astronomy)

Prof Carole Mundell
(Professor of Extragalactic Astronomy)

16 February 2011

Written evidence submitted by Professor Mike Bode, Director of the Astrophysics Research Institute, Liverpool John Moores University (APP 36)

Preamble and Declaration of Interests

1. The Astrophysics Research Institute (ARI) of Liverpool John Moores University (LJMU) has a staff of 23 research astronomers, 16 PhD students and 12 technical and support staff. In an innovative collaborative arrangement it provides all the Astrophysics undergraduate degree teaching in a joint degree programme with Liverpool University. It also owns and operates the 2.0 metre Liverpool Telescope (LT) on La Palma, which is a unique robotic facility for time domain astrophysics for all UK astronomers. Funding for the operation of the LT is in part supplied by STFC. Use of the LT also naturally forms the principal focus of many of the astronomers within the ARI, together with many other users in the UK and outside. Another unique feature of the ARI is its very strong outreach and education programme, where access to the LT is made available to schools across the UK via the National Schools Observatory (NSO) and also to students on specific modules of ARI's large Distance Learning programme. In 2005, the University was awarded the Queens' Anniversary Prize for Higher and Further Education for the work of the ARI, particularly in the development of the LT and the provision of access to schools.

2. I led the formulation of the ASTRONET Roadmap for European astronomy, published in 2008. ASTRONET[35] was created by Europe's major astronomy funding bodies and research organisations, including STFC, to enable the formulation of coherent planning across national boundaries, particularly in an era of increasingly ambitious projects, within limited resource envelopes. ASTRONET first produced a Science Vision for European astronomy for the next 10–20 years. It then formulated the Roadmap, for which STFC was the lead partner, which details those facilities and associated infrastructures that will be required to deliver the Vision. Both the Roadmap and Science Vision entailed extremely wide community consultation. I am currently a member of STFC's Science Board and was recently appointed to STFC's Advisory Panel for Science in Society.

3. I obviously have a direct interest in the continued funding of telescopes on La Palma, in particular the Liverpool Telescope, and also the continued success of the National Schools' Observatory in delivering outreach (fuller details of both projects are given in the separate response of the LJMU Astrophysics Research Institute). The evidence presented here will nevertheless concentrate particularly on items 2 and 4 of the Inquiry.

The Impact of Reduced Capital Funding on UK Capability

4. The ASTRONET Roadmap presented a prioritised list of facilities required to deliver the Science Vision. These were sub-divided into space-based and ground-based facilities, and within these categories, further sub-divided into three bands relating to the likely project cost. In the ground-based, large project category for

[35] See www.astronet-eu.org

example, the European Extremely Large Telescope (E-ELT—optical/infrared) and the Square Kilometre Array (SKA—radio) were ranked with equal highest priority. The UK has had a major role in developing both of these multi-national projects in the expectation that high value outputs in science and technology will flow into the UK when they are realised. The fear is that capital expenditure cuts may result in the loss of our ability to take such leading roles in these, and other, flagship projects, and so we lose return, including potentially lucrative future industrial contracts as a result.

The Impact of Withdrawal from International Ground-based Facilities...on the UK's Research Base and International Reputation

5. There is no doubt that the UK is a leading nation in astronomy and astrophysics research. This has been built to a large extent from its broad technical range giving UK astronomers access to many ways to make investigations in a particular field of our science. In the jargon of astronomy, the UK has access to multi-wavelength facilities, both ground and space-based, and access to both hemispheres. Indeed, such all-sky access is vital in an era of increasing synergy between space missions and ground-based telescopes. One of many areas where this is abundantly apparent is in that of Gamma Ray Bursts (GRBs) where spacecraft detections of these explosions, which occur unpredictably anywhere on the sky, are now followed up within minutes by telescopes on the ground. This synergy has proved essential in determining the nature of GRBs, which turn out to be celestial laboratories for the exploration of extreme physics.

6. Of particular personal concern is the UK's withdrawal from the La Palma site. For the UK, this hosts the Isaac Newton Group of telescopes (including the William Herschel Telescope), SuperWASP (Wide Angle Search for Planets, owned and operated by Queens University Belfast) and the Liverpool Telescope (LT, owned and operated by LJMU), all with significant STFC involvement.. The scientific and technical synergy between the La Palma telescope facilities, operating at a world-class site, provides a range of unique opportunities for UK and international scientists built up with UK leadership over several decades. There is also the potential to further our collaboration with other front-rank facilities on the site, including the 10m GranTeCan telescope which is just coming on-stream. In the specific case of the Liverpool Telescope, this instrument represents the world's largest and most capable fully-robotic telescope providing the UK and the international community with unparalleled opportunities for exploration of the increasingly important time domain of astrophysical enquiry, as emphasised in the latest US Decadal Survey.[36]

7. Within the ASTRONET Roadmap, as well as a requirement for new facilities, the need was also recognised for some restructuring of the organisation of Northern Hemisphere 2–4m class facilities across the whole of Europe It therefore commissioned a detailed review by the "European Telescope Strategic Review Committee" comprising 10 leading astronomers, chaired by Professor Janet Drew (Univ. Hertfordshire), with considerable community involvement. The report is available for download at http://www.astronet-eu.org/IMG/pdf/PlaquetteT2_4m-final.pdf and it is commended strongly to the committee as the most thorough and comprehensive independent review of the question of the future of the northern hemisphere 2–4m class telescopes.

8. To quote from the very first paragraphs of the report:

> *"The panel wishes to note at the outset the general point that it became ever more vivid as it carried out its task that astronomy, as an observation-driven discipline, confronting phenomena ranging from the very bright (naked eye exo-planet hosts and astroseismological targets) to the faintest quasars at the edge of the accessible universe, continues to need access to telescopes in all size classes ... In this respect, our subject is not at all like some other frontier disciplines such as particle physics where it is clear that advances demand a policy of complete facility replacement on decadal time scales. The 2–4m class telescopes support a wide range of research topics and it can indeed be argued that they can offer cutting edge science ... It is also worth noting that there is a rising profile of interest in time domain astronomy, which may involve having the flexibility to respond quickly at [optical/infrared] wavelengths to triggers ... Retaining a broad suite of efficient 2–4m telescopes accessible to Europe's astronomers is, without any trace of doubt, crucial for Europe's presence at the astronomical frontier."*

9. Any decision by STFC to withdraw from La Palma, close down its northern hemisphere involvement and reduce its access to moderate-sized telescopes would therefore represent a retreat from our ability to explore major sections of the astronomical frontier.

Whether the Science and Technology Facilities Council (STFC) has Sufficiently Engaged with its Research Community in these Two Areas on its Strategic Direction and Impacts of Budget Reductions

10. From its inception, and through the first of the Council's Programmatic Reviews in 2007–08, as the Committee will be aware, there was wide-spread dissatisfaction in the research community with the level of information flow and engagement from the Council. This was felt equally by the STFC's panels and committees of researchers who consequently found their task of interaction with the wider community doubly difficult. My personal view is that, although by the nature of things there will always be areas to address, this situation has greatly improved over the last two years thanks to the efforts of STFC and the community.

[36] http://science.nasa.gov/earth-science/decadal-surveys/

11. In my opinion therefore, as long as the current efforts continue to be put into engaging with the community, this is yesterday's problem, and we are faced with more crucial issues.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

12. Astronomical outreach and education has a very important role, not just in inspiring the next generation of astronomers, but much more widely in helping to fill the gap in future provision of experts in all areas of science, technology, engineering and mathematics (STEM). This was highlighted in the extensive study *Pupils' and Parents' Views of the School Science Curriculum* by Osbourne and Collins[37] in 2000 who concluded that "The one topic (amongst the sciences) that generated universal enthusiasm was any study of astronomy"—indeed they found this across age, gender and ethnic boundaries. A central role of astronomical outreach, therefore, is to take that ongoing enthusiasm and turn it into a wider enthusiasm for all STEM areas.

13. This is an area where the UK currently has a world-leading reputation. Projects such as the National Schools' Observatory (NSO) and the Faulkes Telescope project, the success of International Year of Astronomy (IYA2009), the leading role in the creation of "Dark Skies Parks" and many more all show the success that the UK has in exploiting the draw of astronomy.

14. However, to retain our position (and ensure the benefits to all STEM subjects are not lost) then it is necessary to both continually innovate and develop new projects *and* ensure the support for the best existing ones. The situation of the NSO is a good example of the opportunities and problems currently facing both of these.

15. The NSO, which is run by the ARI, is designed to exploit access to the Liverpool Telescope in a unique synergy to showcase both the scientific nature of astronomy, and the exciting technology that underpins it. To do this, an essential aspect of the design and operation of the project is to explicitly work alongside professional astronomers, using similar systems to obtain and analyse observations and facing similar challenges. The main role of the NSO, therefore, is to create and support tools that allow this for a wide range of age groups (KS2 to post-16), abilities (special needs through to the highest ability) and subject areas (not just science, but also mathematics, ICT, Design and Technology etc).

16. In all this, the linkage to front-rank research is clearly essential—it is very important not just that the telescope is very large and highly sophisticated, but that it is the same telescope that is being used by UK astronomers to make headline-grabbing discoveries. That connection is what will inspire pupils to believe that they too could make such discoveries for themselves in the future.

17. The NSO currently has over 2,000 schools registered. The majority of these are state-funded secondary schools with a national geographic spread. More than 24,000 observing requests have been successfully carried out for schools since the start of operations in late 2004, and the rate of requests is increasing rapidly (there were 7,000 requests successfully delivered to schools in 2010, and more than 1,400 in January 2011 alone). In addition to use by registered schools, the NSO website receives between one million and two million "visits" per year, the majority from within the UK. Drops in traffic during half-terms show that this is use by schools. Projects undertaken by pupils range from simple observations of planets or the Moon, through to genuine research projects such as the study of asteroids, monitoring of distant supernovae and searching for extra-solar planets.

18. As well as direct benefits, the NSO provides a focus for other education and outreach. For example, as part of IYA2009, NSO astronomers gave inspirational presentations to about 15,000 KS4 pupils across the country. Teacher training is also an important component of our work, with hundreds of teachers each year being provided with CPD by NSO staff. In recent years this has often supported the provision of GCSE Astronomy in schools—one of the fastest growing qualifications in the UK and often taught in out-of-school clubs, which is another indication of the inspirational power of astronomy.

19. On any measure therefore, the NSO is a very successful and inspirational resource, but like many others, it has continually faced the challenge of long-term funding. Currently, it is funded by LJMU, who also provide the telescope time from its reserved fraction, thus ensuring "free" access to schools, although of course the University itself faces a very tough financial climate overall.

20. Direct funding at any significant level from central educational bodies (the Ministry, LEAs etc) has not been forthcoming, as these bodies see such exploitation of research facilities as falling within the remit of the research councils. In contrast STFC (and previously PPARC), within limited funds for outreach activities, have perhaps inevitably given low priority to supporting ongoing projects—they are interested in developing new initiatives. Therefore the NSO, like many other outreach and educational projects, falls between two stools and currently alternative avenues of funding are being actively explored (including commercial exploitation or extensive new developments into Europe). The likelihood would however be that such alternative funding sources would remove the 'free at the point of delivery' nature of NSO, thereby having the most detrimental impact on the schools who might most benefit from exposure to the project.

[37] http://www.kcl.ac.uk/content/1/c6/02/21/14/pupils.pdf

21. In addition to its primary research function, the Liverpool Telescope is obviously central to the operation of the NSO by providing UK schools with access to time on this front-rank research facility which in turn allows access to research-quality data for experimentation in the classroom. An alternative model, should the LT not be available, would be to run the NSO via access to other telescopes. However, the NSO is designed to exploit the fully robotic nature of the LT, with its extensive instrumentation suite and location on an international observatory site. Moreover, if a suitable telescope could indeed be found, which currently would be outside STFC's and ESO's remit, such telescope time would need to be purchased which would clearly be far more expensive than "piggy-backing" on the UK research effort. Since the current, and unique, dual use of the LT by UK astronomers and schools also has significant inspirational and educational advantages, this is very much the preferred approach.

22. To summarise, the LT and the NSO represent a unique synergy that a retreat from the La Palma site would threaten to destroy. The specific case of the NSO also highlights a significant problem in the current astronomy education and outreach effort. The UK has a world-leading role in developing exciting new links between research and education that are essential if we are to inspire the next generation of scientists and engineers. However, once those links have been developed and are shown to be effective, there are no clear routes to support their continuation and they may die. While such issues fall between the Research Councils and DfE, and neither are willing and/or able to take ownership, this unfortunate situation will continue.

Professor Mike Bode
Director of the Astrophysics Research Institute
Liverpool John Moores University

16 February 2011

Written evidence submitted by Professor John Peacock (APP 37)

1. I am writing to give my personal views on some issues relevant to your inquiry into astronomy and particle physics in the UK. I am Head of the Institute for Astronomy at the University of Edinburgh, and a Fellow of the Royal Society. The IfA is in receipt of approximately £1.5 million pa in STFC research funding, and is co-located with the STFC's UK Astronomy Technology Centre.

2. Your first question concerns the impact of reduced capital funding on UK capability. I think it is necessary to broaden this to consider the general funding situation and its history, since our current position is the outcome of a crisis in the funding of astronomy that has unfolded progressively since CSR07 and the creation of STFC, and complicated by the 2010 creation of the UK Space Agency. Nevertheless, it is possible to look back at the areas of UK astronomy and particle physics that were once supported by PPARC (the Particle Physics and Astronomy Research Council) and which are still within the remit of STFC, and to ask how things have changed—and why.

3. For convenience of access to relevant figures, I take a baseline year of 2005–06. I assume total inflation of 10% to convert to present-day figures. In 2005–06, I estimate that real spend on what would now be termed development, operations, or exploitation was roughly £72 million (astronomy, including solar system) and £55 million (particle physics, including particle astrophysics). The current figures are respectively £50.4 million and £44.6 million, or an average cut of 25%. But this severely underestimates the problem, since research grants have moved to "full economic costing", which approximately doubles the grant overheads paid to universities. This shift was intended to be cost neutral for the UK, transferring funds to research councils that were previously paid direct to universities. FEC grants had barely begun in 2005; in order to maintain the 2005 level of science, the real funding needed is approximately now £84 million (A) and £64 million (P). The actual figure is only 64% of this, with astronomy being hit harder. This imbalance is set to increase: by 2014, the UK will have withdrawn from the Gemini observatory, and STFC's planned astronomy total declines to £42.2 million—a 50% real cut from 2005.

4. The magnitude of these cuts is apparent in the most recent STFC grants round, where 56 new positions for Postdoctoral Research Assistants in astronomy were approved; the 2005 figure was over 100. This hugely reduced funding reduces the capability for existing active researchers to push projects forward and also removes a good part of the career ladder for our most promising young researchers. This is bound to threaten the position of UK astronomy and particle physics on the world stage, where we are currently considered second only to the USA.

5. In broad terms, something like £50 million pa has been removed from funding of research: where did it go? The main place to think of looking would be the large international subscriptions. CERN (£81.8M) is actually slightly smaller in real terms than in 2005. ESO (£11.6 million) is very much smaller than in 2005 (£19.1 million). But this difference was planned and expected at the time of joining ESO (2002), since the UK had to make additional payments above its subscription as a "joining fee". From this point of view, the statement you heard in previous evidence from Keith Mason that "*we recognised that in joining ESO we would be over-investing in astronomy for a period of a decade*" is correct. But this statement seems intended to imply that joining ESO rendered the UK's other telescopes redundant, and I would contest this. Joining ESO was seen as a way of preventing European astronomers from eroding our world-leading position, and the community

was unanimous that our existing telescopes retained a strong scientific role. This conclusion was reiterated as recently as 2009 in the Ground-Based Review sponsored by STFC.

6. The only large change in international subscription that was unanticipated in 2005 is the European Space Agency. The real-terms subscription in 2005 was £61 million, and this was expected in 2005 to stay roughly constant. In fact, the total rose to £91 million, at which point responsibility for paying the ESA subscription was transferred to the UK Space Agency. This large increase arose from a ministerial-level decision, and does benefit the UK in terms of *juste retour* of ESA-related work to UK space industry. But it seems that this benefit has been gained at the expense of investment in scientific research within UK academia.

7. If the rise in the ESA subscription can account for roughly half the decline in funding for astronomy and particle physics research, the remainder seems attributable to the problems arising from the formation of STFC: these started immediately after CSR07, when it was announced that STFC faced a shortfall of £80 million over the following three years. Nevertheless, the ex-PPARC community was assured from various directions that STFC's budget was set to rise 13% over the CSR period relative to the sum of the PPARC and CCLRC budgets prior to the merger. No-one could understand how it could be that we immediately needed to make deep and painful cuts to our programmes if funding was rising. I eventually concluded that this was largely down to the way Treasury accounting rules were applied to research councils: capital allocations were in effect only a loan, since the value of capital assets had to be shown as depreciating. The portion of the declared budget that covered this depreciation (termed "non-cash") could not be spent. The impact of this rule on PPARC was very small, since it owned few capital assets: in 2005, non-cash amounted to about 3% of the total PPARC budget. But for STFC, non-cash amounted to about 15% of its budget—and this unspendable fictitious money rose, so that it accounted for the entire claimed increase in spending. The need for this large non-cash "repayment" was dominated by the construction costs for the Diamond light source at RAL. Under STFC, the science programme at Diamond has undoubtedly suffered heavily as a result of this strange application of Treasury accounting process, which is regrettable; but equally it is clear that ex-PPARC science has taken a share of this burden. If STFC had not been formed, the bill would have been confined within the CCLRC budget.

8. The best that can be said of this unfortunate saga is that the main problems are unlikely to recur: the ESA subscription is now the responsibility of the UK Space Agency, and I understand that the concept of a non-cash allocation has been disposed of in the recent CSR. But this stability has been achieved at the bottom of the market; even though STFC received as good a settlement as could be envisaged in the current financial climate (constant cash), this simply consolidates the factor 2 drop in funding that is analysed above, and continues with a further slow decline. There is no hint of any attempt to reverse the decline—even though it is hard to imagine that such a savage cut could be an act of deliberate policy. In complaining about loss of funding, scientists risk radiating a sense of entitlement to public money, and this is an impression we must avoid. But what we can legitimately demand is *stability*: society needs to decide what it wishes to spend on relatively abstract activities like astronomy and particle physics, and then stick to its bargain. Young scientists of great talent will plan accordingly, and some will choose to dedicate their lives and careers to a given subject, and to pursuing it in the UK. But no-one can plan sensibly in the fact of a 50% cut; unless we start to reverse it, the damage will be felt for decades.

9. In this financial situation, UK scientists are desperate to achieve the very most with their remaining funding and facilities. There is a tension between the large and expensive international facilities provided by ESO, and smaller facilities under our own control. As a treaty organization, we have no control over the ESO subscription; having paid the admission fee for this club, there is then a persuasive argument that we should invest in that direction to gain value from our membership (the "no point joining a golf club if you can't afford a set of clubs" argument). Certainly, the UK has not been able to invest as much as it wished in building instrumentation for the ESO telescopes. But in the end ESO is a shared resource for all European astronomers, and so it is not easy for the UK to gain a competitive advantage. This is why it has been seen as essential to retain also our own telescopes, which we can turn into specialized facilities delivering data that can be combined with ESO results in a way that is not available to our European colleague-competitors. Thus the long-term strategy has been very much to continue a presence in the telescopes in Hawaii and La Palma—but accepting that they should be operated much more cheaply. This has been achieved with great success, and the policy should continue. Current funding plans for these observatories currently do not reach beyond 2012, but there is ample scientific reason to persist with them, assuming a very modest level of funding can be found. Withdrawal from Gemini could be tolerated in this picture because it was not a UK-owned facility, and the overlap with what ESO provided was larger.

10. From this point of view, some reduction in capital funding can be tolerated in the short term. If taken too far, it can however cause difficulty in simply keeping existing systems functioning: there is some concern that the levels of capital available to STFC will limit even the provision of basic requirements like new computer hardware. Probably we will muddle through; but in due course, capital provision will need to rise. The need for unique UK facilities of modest scope will remain, and there are many new opportunities where the investment of even a few £million can position the UK so that it follows a new trend that complements our existing facilities and enhances their value. An example of a past investment of this sort is our membership of the US-led Dark Energy Survey. If we cannot continue to maintain a portfolio of such new activities, then the future is inevitably one of decline. We will be seen as living off our past reputation, and ripe to be overtaken.

11. All the problems documented above have exposed a number of problems with STFC. It is no secret that the community has been extremely unhappy with the STFC Executive over the past three years. The main charges would be a failure to explain how and why the reductions in funding arose; a failure to sympathise sufficiently with complaints from the areas being cut; an apparent desire to repeat the government message about funding having risen when it was obvious that this was an illusion; and a perceived general reluctance to complain and criticize the government policies that had let to such a situation. An almost total breakdown in trust has occurred, so that statements such as the one on the future of non-ESO telescopes heard by previous sessions of this Committee are presumed to reflect an ulterior motive that is against the interests of the research community. These views are arguably paranoid, but they would not have arisen with better leadership.

12. More seriously, it seems clear that there are serious structural issues with the current dispensation. STFC faces an impossible conflict of interest, in that it is both a commissioner and a supplier of research. When funds are tight, STFC has to decide between cutting research grants to universities, or failing to support its own in-house research facilities. It is inevitable that any organization will tend to favour those things that are directly under its own control, especially as research grants to universities have greater practical flexibility as a tap that can be turned on and off. There is a widespread perception that STFC has become inward-looking, with its attention heavily focused on RAL in particular, and with academia treated as a secondary tier of its business. Again, this could be seen as a kind of paranoia, which started as soon as the STFC name was seen to contain "facility", but not "research". Nevertheless, the perception is widespread, and is not helped by the governance arrangements: the number of active research scientists on STFC Council has declined in favour of members with expertise in industry. There seems to be an argument that those in receipt of research grants cannot be disinterested; but this is not the case with other research councils, and I feel that STFC urgently needs to start rebalancing its high-level decision-making in favour of researchers. No single step would do more to start to win back the trust of the research community.

13. Finally, you ask about the impact of all this on outreach and inspiring the next generation of young scientists. Despite the saying that there is no such thing as bad publicity, the impact has clearly been hugely negative. Even non-scientists are frequently aware that UK science is in trouble, so you may be sure that young people of a scientific leaning are getting a clear message. I think they are still inspired by science, so it is more a question of whether they see their future in the UK or abroad—and also of whether they feel a confidence that the UK is giving them the best foundation. When I was a student, I gained a clear feeling that there was no better place in the world for learning and doing science. Perhaps that was over-confidence, but such pride is no bad thing. It's interesting to contrast the way the public is encouraged to celebrate UK sporting prowess in the run-up to the Olympics (and to think what these have cost). In science, we have the impact agenda, and all publicly funded scientists are very happy with the idea of making a contribution back to society through their work—but there is a danger if this laudable aim starts to be seen as the prime purpose. The Olympics, of course, are valued by government for their economic impact: but the public message is one of celebrating sporting achievement and being the best in the world as of prime importance in its own right. I don't see the same sense of pride being taken in our brilliant young scientists, and a more positive and idealistic message would be good both for the country and for stimulating this next generation into keeping the UK at the forefront of the world of scientific ideas.

Professor John Peacock FRS
Head of Institute for Astronomy
University of Edinburgh

17 February 2011

Supplementary written evidence submitted by Professor John Peacock (APP 37a)

Thank you for the opportunity of appearing before your committee to present some of the concerns of the academic community of researchers in astronomy. We now write in response to the remarks made to your committee last week by the STFC Chief Executive, Professor Mason, in support of his assertion that there has been an "overinvestment" in astronomy and that a strategic plan leading to withdrawal from the northern hemisphere observatories was developed at the time of our accession to the European Southern Observatory. Professor Mason quoted a fragment from a PPARC Council paper of December 2001; we note that this paper makes no mention of any plan to withdraw from the Gemini Observatory, a major step that is now a fait accompli. In addition, the position advocated by Professor Mason is not incorporated in subsequent strategy documents (for example, the 2005–2008 delivery plan). We do not believe that the comments you heard fairly represent the strategy that was in place at the time of ESO accession.

Examining the record of consultations with the community that took place around the time of the decision to join ESO, one sees a very different picture from the one painted by Professor Mason. An extraordinary meeting took place at the Royal Astronomical Society on 22 June 2000, reported in Observatory, 120, 375. The principal speakers were Eric Priest as Chairman of the PPARC Astronomy Committee, and Ian Corbett as PPARC Director of Research. Both spoke of the need to find savings of £5 million p.a. from current programme, by withdrawing from the AAT and seeking leaner operation elsewhere. Priest: "This could be, for example,

not by closing ING but by simplifying the operations ... by withdrawing funding from the AAT ... by simplifying operations at UKIRT and JCMT". Corbett: "A possible scenario to release £5 million per year is by withdrawing PPARC support in whole or in part from the ING, the AAT and MERLIN, and reducing the operational level of JCMT and UKIRT".

Following this outline presentation to the community, a detailed consultation process culminated in the strategy review held by the PPARC Science Committee on Nov 27/28 2001. The Science Committee was the final stage of preparing scientific advice to PPARC, and its decisions can be taken to represent the distilled will of the community. That meeting considered a "strategic plan for astronomy" from the PPARC Executive, which in part grew out of the "Ward Panel" report on "Restructuring the ground-based astronomy programme" (which was presented to Science Committee on 9 April 2001). In the minutes of the Nov 2001 meeting, the main recommendations were given in so many words as: Withdraw from AAT, INT, JKT; JCMT & UKIRT to move to survey mode; reduce UK share of WHT to 40% (minute 6.10). Minute 6.15 further states that the committee agreed to "endorse the proposed restructuring" and to "recommend that Council endorse UK membership of ESO". This was clearly the critical date at which the community identified the reductions in capability needed to make ESO membership feasible. Science Committee endorsed a strategy that is in essence exactly the one that we have followed—leaving aside the critical point of UK withdrawal from Gemini, which was not even contemplated in 2001. With the loss of Gemini, and the corresponding serious damage to our observational capabilities in the Northern hemisphere, the UK astronomical community has made more than double the savings identified as needed in order to join ESO.

The December 2001 PPARC Council meeting referred to by Professor Mason seems to have heard and accepted this proposal. Minute 24 of that meeting states "The community had endorsed this package by accepting re-structuring of its existing ground based facilities and savings in the order of £5 million to free funds in its support". The "loss of current facilities" in minute 28 is a clear reference to the partial closures listed above. The statement that the "long-term strategy will see PPARC withdraw from the AAT, JCMT, UKIRT and the ING by the end of the decade" is found only in a paper on ESO prepared by the PPARC Director Programmes (Professor Wade). This paper is not specifically endorsed in the Council minutes of that meeting, and we cannot understand this statement given that it did not appear in any of the community strategic discussions discussed above. Moreover, it is not to be found in subsequent strategy documents (for example, the 2005–08 delivery plan http://www.stfc.ac.uk/resources/pdf/delplan0508.pdf).

In summary, it seems to us that the statement of the STFC Chief Executive does not correctly reflect the clear strategic position developed with regard to the non-ESO telescopes at the time of ESO accession. We note that Professor Mason was present at the Nov 2001 Science Committee meeting and thus endorsed this very strategy. The idea that this process might be overturned by a single sentence in a paper developed by the PPARC Executive is hardly credible, unless one favours the sort of decoupled decision-making that has been strongly criticised as an undesirable trait of the early days of STFC.

Professor Mike Bode

Professor Roger Davies

Professor Rob Kennicutt

Professor John Peacock

Professor Steve Rawlings

21 March 2011

Written evidence submitted by Professor Patrick Roche, Head of Astrophysics, Oxford University (APP 38)

Please find attached a submission on behalf of Oxford Astrophysics, a sub-department of Physics at Oxford University. I concentrate on issues relating to ground-based optical infrared astronomy.

Statement of Interests

My interests are in astronomical research and instrumentation. I am currently a UK delegate to ESO Council, a member of the ALMA Board and Chairman of the UKIRT Board.

The Impact of Reduced Capital Funding on UK Capability

1. The current high UK reputation in Astronomy and Space Science reflects investments made in the period from the 1970s to the present. Over this time, the UK built up a portfolio of facilities that allowed astronomers to conduct many breakthrough programmes. These include the Anglo-Australian Telescope, the UK Infrared Telescope, the William Herschel Telescope and the James Clerk Maxwell millimeter wave telescope. The UK has a world-leading record in telescope operation which, with a carefully-crafted instrumentation development programme, has maintained each of these facilities at the forefront of astronomy. Independent assessments have ranked them as the most productive in the world in their research areas and ahead of almost every other

similar facility.[38] The scientific programmes enabled by these telescopes is a major factor in the renaissance of UK astronomy over the last 40 years.

2. To remain competitive, UK astronomers needed access to larger and more expensive facilities and in the early 1990s we joined together with the USA and Canada to form the Gemini project and then in 2002 we joined ESO. Accession to ESO resulted in substantially increased access to telescopes in the southern hemisphere, and enabled the construction of the Atacama Large Millimetre Array (ALMA). The buy-in to the ESO infrastructure consisted of in-kind and cash contributions spread over almost a decade. The additional contributions to ESO will finish in 2012, and the UK subscription levels will fall thereafter.

3. In order to reduce expenditure on ground-based telescopes, cost savings were made in the telescope operations. The UK withdrew from the Anglo-Australian Observatory in 2010, ramping down our contributions over several years in a managed withdrawal agreed with our Australian partners. The ramp-down followed the supplementary agreement to the Anglo-Australian Telescope Act signed in 2006, and has left the new Australian Astronomical Observatory as a strong and viable organization.

4. In response to the STFC funding crisis, the operational costs of all UK facilities have again been examined. The UK IR Telescope in Hawaii has adopted a new operational model (the so-called minimalist mode), wherein the telescope is operated remotely from sea-level. Astronomers in Korea have purchased observing nights on the telescope (50 nights in 2011) further reducing the cost of operations to the UK, down to a level that is first/third that of a few years ago, though at a cost of a reduction in observing time available to UK astronomers. Similar economies have been made in La Palma.

5. These savings enable the facilities to continue operating, but do not provide a long-term future, as they will only be competitive if new investments in instrumentation are made. In the current funding regime, this is unlikely and proposals for new instruments, eg for the proposed UKIRT Planet Finder, an instrument to detect earth-mass planets around nearby cool stars, have not succeeded. The provision of instrumentation for existing telescopes as well as the construction of proposed new, high priority, facilities such as the European-Extremely Large Telescope and the Square Kilometre Array could be very badly impacted by reductions in capital funding.

The Impact of Withdrawal from International Ground-based Facilities (for Example the Gemini Observatory and Isaac Newton Group of telescopes) on the UK's Research Base and International Reputation

6. Our partners and competitors in other European countries have maintained independent telescopes in addition to those provided by ESO. For example, France is a partner in the Canada-France-Hawaii telescope in Hawaii in addition to operating domestic facilities, while German institutions are partners in the Large Binocular Telescope in Arizona as well as the Calar Alto Observatory in Spain. Spain has major observatories in La Palma and Tenerife, including the 11 m Gran Telescopio Canarias. If the UK withdraws from the northern hemisphere sites in Hawaii and La Palma, we will have no such independent facilities, relying solely on access to the ESO telescopes, and further weakening our competitive position. This will also make the development of innovative UK-led instrumentation projects much more difficult; we will lose our direct access to smaller telescopes and the smaller scale instrumentation developments associated with them. Such projects can often be undertaken by individual research groups, where opportunities for innovative design and hands-on experience for students and postdocs are much greater than in large consortia.

7. The ESO telescopes are very well placed to probe the southern sky stretching to the southerly parts of the north, but cannot access the northernmost quarter of the sky at all. Whilst some projects do not require observations in particular regions, loss of access to northern hemisphere telescopes could seriously hamper other branches of astronomy. Space telescopes usually operate all over the sky, and we would be unable to make further measurements of some of their discoveries. For example, the UK has made a substantial commitment to ESA's €500 million GAIA satellite which will survey the whole sky to map the detailed structure of our own Galaxy. Together with other partners, UK astronomers have proposed a new instrument for the William Herschel Telescope as recommended by the EU-ASTRONET European Telescopes Strategy Review Committee report. We are working with STFC to help develop a new operational model for the UK telescopes on La Palma within the wider European context called for by the ETSRC report. The UK has built substantial programmes around the northern telescopes, and is continuing to do so. For example, the new LOFAR station at Chilbolton, Hampshire, which opened in 2010, feeds into the Low Frequency Radio Array in the Netherlands, which will stimulate further observational follow-up in the north. The Goonhilly ground station developments will link into the MERLIN telescope based at Jodrell Bank, again relying on observations in the north to fully characterize objects detected. The UKIRT telescope in Hawaii has conducted the first deep sky surveys over significant areas of the sky at infrared wavelengths and has recently discovered the nearest, coolest brown dwarf and the furthest quasar. Rare objects with extreme properties are of particular significance as they allow us to test theories at their limits and they can occur anywhere in the sky.

8. Following the budget crisis of 2007, the STFC indicated that it may have to withdraw from the Gemini observatory. This announcement was made with little notice and apparently little engagement with our partners. In my view, it badly damaged the UK's reputation as a reliable and responsible international partner. Whether

[38] eg Trimble, V & Ceja, J, 2008. Astron Nachr **329**, 632. Trimble, V & Ceja, J, 2010, Astron Nachr **329**, 338

it is entirely accurate can be disputed, but the Wikipedia entry on the Gemini Observatory[39] states *"This decision significantly disrupted observatory budgets, and resulted in the cancellation of at least one instrument in development at that time (the Precision Radial Velocity Spectrograph)."* The reputational damage is clear. Since 2008, the STFC has greatly improved the communication and interaction with the community and their partners.

9. I do not accept the argument that the large reductions in Astronomy funding were part of a long-term plan. The STFC was underfunded at the outset, largely because liabilities were carried over from other (non-PPARC) parts of the science programme absorbed by STFC at its formation. The cuts announced in 2007 and 2008 were a direct reaction to this, and have led to reductions in the numbers of postdoctoral researchers in astronomy supported by STFC to below the levels supported a decade ago. This clearly has a large impact on the prospects of young scientists continuing research careers in their field in the UK.

10. Telescope facilities can easily take a decade to design and build, followed by one to five years of commissioning and ramp-up and 10–30 years of exploitation. Once projects are committed, they can take 20 years or more to return the investment. Sharp changes in funding levels endanger exploitation of the facilities and in the worst cases mean that the returns on the investments are not made. The measures taken to provide stability in facilities funding should help significantly, but long-term funding is required to conclude projects successfully.

Opportunities for, and Threats to, Outreach and Inspiring the Next Generation of Astronomers and Particle Physicists

11. Current investments will bear on the UK reputation in the second half of this decade and beyond. Whilst the ESO programme provides forefront science facilities beyond those that can be provided by individual member states, it does not aim to provide all of the facilities for national astronomy programmes; indeed that is beyond its stated remit. Astronomy is a broad subject, and advances come from both large, expensive facilities and smaller scale projects. Preservation of the latter is vital to the health of the subject, and especially to the training and development of students and postdocs. There is real danger that the hard-won UK reputation in astronomy may be undermined by the reductions in funding at a time when many of our competitors are maintaining or even increasing their funding in recognition of the role that astronomy plays in attracting people to science and the importance of training.

12. We have a strong and vibrant astronomy and physics outreach programme at Oxford. We both attract schools to the Physics department and undertake visits to schools. These programmes rely on the enthusiasm and goodwill of everyone, including students, postdocs and staff. Oxford is the home of the Galaxyzoo[40] programme which has engaged hundreds of thousands of people in citizen science activities through its innovative approaches to outreach and the promotion of science, coupled with the contributions of the volunteers. These programmes will continue and expand, but rely on motivated and enthusiastic researchers to carry them forward. Maintenance of the morale of our young scientists is absolutely key to these activities, and that is achieved by maintaining their prospects for a career in the subjects they love. The last few years have been very damaging in this respect.

Professor Patrick Roche
Head of Astrophysics
Oxford University

16 February 2011

Written evidence submitted by Professor Phil Allport, Head of Particle Physics, Director of the Liverpool Semiconductor Detector Centre, Chair, Institute of Physics High Energy Particle Physics Group, University of Liverpool (APP 41)

Dear Andrew

Thank you very much for the opportunity to present evidence yesterday. You asked for details about the survey I referred to. This developed from the widespread concern about job prospects for current UK post-docs in particle physics, leading a Liverpool post-doc at CERN (Paul Laycock, who is also ATLAS Deputy Calibration Manager) to somehow find the time to put together a web based survey (with summary to be found at http://hep.ph.liv.ac.uk/~laycock/PhysicsCareersSurvey/Results.html) which was circulated among the UK community mostly working on CERN based experiments. The respondents were mainly either employed by UK institutions or from other collaborating institutions in the 83 countries with formal links to CERN. The survey is biased in that it mainly addresses those who are still employed in the field, predominantly has responses from those working at CERN, and of course reflects the view of those willing to take the time to complete the survey. Nevertheless, as I said in my evidence, I do think some clear patterns emerge that help give weight to the strong concerns about prospects for UK employment being expressed by those who are just starting out on careers in this area.

[39] http://en.wikipedia.org/wiki/Gemini_Observatory
[40] http://www.galaxyzoo.org/

I wonder if I could also raise another issue. In the evidence of Professor Mason, he clearly believed I had not understood the proposal concerning concentration of detector construction activities "in-house" at the national laboratories. I had within the previous month sat with both the Director Programmes STFC (Professor Womersely) and the Chief Operating Officer STFC (Professor Wade) and I believe I fully understand what is being proposed. My concern was not where R&D is to be carried out (as I believe Professor Mason assumed) but the actual construction work. The very largest university particle physics groups have major construction capabilities and unique expertise. The largest arrays of silicon detectors ever constructed in the UK (the ATLAS semiconductor tracker barrels and the 9 disc EndCap-C (amounting to roughly 500,000 square centimetres of silicon sensors) were assembled and tested at Liverpool and Oxford, with modules sent from 30 institutes in 12 countries for assembly at these sites. In the Liverpool Semiconductor Detector Centre (LSDC), of which I am Director, we have built modules and assembled the full array for the ATLAS EndCap-C, all the LHCb Vertex Locator modules, the vertex detector of the ALPHA (anti-hydrogen) experiment, a third of the T2K ECAL, and many smaller projects. We also lead (like Oxford, Imperial College and other large groups) significant aspects of the LHC General Purpose Detector (ATLAS and CMS) upgrade prototyping internationally, with the ATLAS and CMS Upgrade Coordinators at Liverpool at Imperial respectively. The UK is also poised to take major leadership in the LHCb upgrade activities (were these to be supported by STFC).

The point I want to make is that future construction effort will also have to be at institutions which are fully engaged in the physics exploitation and this is the model that applies to those aspects carried out both in the universities and in the national laboratories. The model being proposed by STFC is to separate construction from those who understand the project intimately and who are involved at the highest level in the international collaborations and lead much of the planning. This goes against accepted practice everywhere else in the world and, I and many others believe, can only lead to a huge loss of UK capability and leadership if implemented. Their current plans also threaten the continuation of the large scale investment in capabilities and expertise to be found in the largest UK university groups, which are also so essential to providing an excellent training-ground for the technologists of tomorrow. Given where the largest recent construction activities have been concentrated, I do find their proposal perverse and potentially highly damaging. I must of course fully declare my interest as Director of the LSDC and as the coordinator, internationally, of the ATLAS Upgrade programme.

With thanks again for all the time the Science and Technology Committee has devoted to this business.

Professor Phil Allport
Head of Particle Physics
Director of the Liverpool Semiconductor Detector Centre
Chair Institute of Physics High Energy Particle Physics Group
University of Liverpool

17 March 2011

Written evidence submitted by Andrea Fesmer (APP 42)

(PHYSICS TEACHER ACCOMPANYING JESSICA GRAINGER, WITNESS ON WEDNESDAY 9 MARCH 2011)

I have taught secondary school physics since 1987 and worked as an IOP Teacher Network Co-ordinator from 2008. I have delivered INSET to physics and trainee teachers, acted as a liaison tutor for PGCE students, delivered workshops to primary and secondary pupils and their teachers in and around Halton. I am on the Board of The National Schools' Observatory.

A. In the Classroom

During the course of my teaching I have seen numerous examples of astronomy inspiring my pupils.

1) *Using the National Schools' Observatory*

Pupils really appreciate being able to use equipment used by astronomers at universities during my physics lessons. It was fantastic to be the first school in the country to use The Liverpool Telescope and watch the excitement on pupils' faces being able to use a multi-million pound piece of equipment. Whether it is "hunting for asteroids" or explaining how to order images from the Liverpool Telescope, or why a telescope is on the top of a mountain it makes all the difference to the pupils understanding and their interest in the subject. They also see that it involves more than looking through a telescope and the possibilities of various careers.

2) *Using the STFC Moon dust samples*

Pupils' eyes light up at the prospect of handling the Moon dust and the meteorite samples. The number of questions that follow and the amount of extra work that is voluntarily undertaken is difficult to believe with some groups.

3) *Having astronomers in the lesson*

Pupils really enjoy the chance to listen to and question a real astronomer. They get excited for weeks about all the questions they can ask.

4) *Watching DVDs of Astronomy lectures or astronomers explaining their research*

Pupils are very keen to listen to astronomy lectures such as Dr Andrew Newsam's IOP lecture or small film clips of astronomers explaining about their work. The girls' in particular like the idea of watching physicists and astronomers at work.

5) *A visit from the STFC Starlab*

Mr Alan Brown from Daresbury Labs brings the night sky alive in the mobile planetarium Starlab. The excitement mounts as the Dome is inflated in the school hall, it even brought the Head out of his office to investigate!

6) *Watching space programmes from television*

After the BBC Stargazing Live programme this year numerous pupils returned to class having watched the programme to ask questions and follow up things they had found interesting. The same thing happens with Brian Cox's series but mainly with the girls!

(The pulling power of astronomy was also revealed when 183 members of the public, of all ages, turned out on a wet and cold January evening for a BBC Stargazing Live event I organised for IOP in Wrexham.)

B. On School Visits

I have organised a variety of trips for pupils, including The Astrophysics Research Institute, Spaceport, Jodrell Bank, CERN, Daresbury Labs and a garden shed (private observatory). The pupils are always keen to learn much more after their visits and enjoy the chance to look round and see science in action.

1) *The Astrophysics Research Institute and Telescope Technology Limited*

Pupils have really valued seeing and hearing from astronomers in their work place. They enjoyed visiting the factory where the Liverpool Telescope was made so they could see for themselves the size of the telescopes and understand the engineering challenges. They also had chance to see less well known career examples.

2) *Jodrell Bank*

Seeing the dish for the first time close up was a talking point for quite some time. They also enjoyed being taken behind the scenes to meet astronomers.

3) *The Garden Shed (Private Observatory)*

A group of sixth formers missed an 18th Birthday party to spend extra time observing the stars and planets with Dr Steve Barrett in his garden observatory. The next visit we did not return to school until around 11.30pm after we had got carried away again!

C. Pupil Space Workshops with PhD Astrophysics Students

I worked with more than 10 Primary schools from the Halton area and eight Halton secondary schools. There was also a series of NSO workshops for Aim Higher Merseyside with year 5 and 7 pupils from schools from all over Merseyside; again the feedback was excellent from both pupils and staff. The pupils valued the chance to meet a real astronomer and began considering careers in science. Teachers were delighted by their pupils' enthusiasm for the NSO, especially some of the pupils who struggled with their work and the more disruptive ones, who miraculously stopped being disruptive!

D. Teacher Workshops and Lectures

To inspire children you need to inspire their teachers. I have organised four IOP conferences for teachers of physics at Bangor University and I always included either a workshop or lecture from staff at The NSO as their resources are always very well received by trainee and practising physics teachers. The feedback and comments received after the conferences show that the resources have been used in the classroom and enjoyed by staff and pupils. The fact that they are free makes it easier for schools to use them.

It would be a great pity if the Liverpool Telescope and NSO were no longer available to use in my classroom or workshops as it brings astronomy research closer and inspires pupils, trainee teachers and teachers. Other schools are not as fortunate as ours in having links with various research establishments, so the NSO gives

every school the opportunity to bring research into the classroom without organising trips or bringing people in and is accessible to every pupil, teacher and school in the country.

Andrea Fesmer
Physics Teacher, Saints Peter and Paul Catholic College (part time)
Institute of Physics Teacher Network Co-ordinator for North Wales

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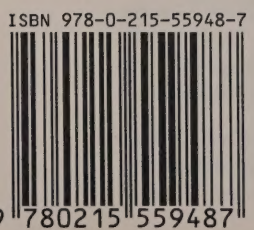

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